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Competitiveness productivity and trade: with special reference to Greece. VDM Verlag,
Saarbrücken. ISBN 9783639219777. [Book]

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List of Abbreviations

ADL:	Autoregressive Distributed Lag
CR:	Concentration Ratio
DEA:	Data Envelopment Analysis
ECLA:	European Classification System
ECM:	Equilibrium Correction Model
EERM:	European Exchange Rate Mechanism
EMU:	European Monetary Union
EU:	European Union
FE:	Fixed Effects
FGLS:	Feasible Generalised Least Squares
FPE:	Factor Price Equalisation
FPI:	Factor Price Insensitivity
GDP:	Gross Domestic Product
GGDC-ICOP:	Groningen Growth Development Centre-International Comparisons of Output and Productivity
GGDC-KLEMS:	Groningen Growth Development Centre- Capital-Labour-Energy-Materials-Services
GMM:	General Methods of Moments
H-O:	Heckscher-Ohlin Model
H-O-V:	Heckscher-Ohlin-Vanek Model
IBC:	Industry Business Class
ICP:	International Comparison Project
ILO:	International Labour Organisation
IPO:	International Property Organisation
ISIC:	International Standard Industrial Classification
IV:	Instrumental Variable
LDV:	Lagged Dependent Variable
LPI:	Labour Productivity Index
LSDV:	Least Squares Dummy Variables
NACE:	<u>N</u> omenclature statistique des <u>A</u> ctivités économiques dans la <u>C</u> ommunauté <u>E</u> uropéenne
NSSG:	National Statistical Service of Greece
OECD:	Organisation for Economic Co-operation and Development
OECD-STAN:	Organisation for Economic Co-operation and Development Structural Analysis Database
OLS	Ordinary Least Squared Estimator
PCSE:	Panel Corrected Standard Error
PIM:	Perpetual Inventory Method
PPP:	Purchasing Power Parity
R&D:	Research and Development
RTFP:	Relative Total Factor Productivity
RULC:	Relative Unit Labour Costs
SCAI:	Scale Intensive Group
SCIB:	Science Based Group
SDOM:	Supplier Dominated Group
SPEC:	Specialised Group

TFP:	Total Factor Productivity
TFPG:	Total Factor Productivity Growth
TSCS:	Time-Series Cross-Section
ULC:	Unit Labour Costs
UNESCO:	United Nations Educational Scientific and Cultural Organisation

Acknowledgements

I need to make crystal clear that the completion of this thesis does not exclusively reflect the effort of the author. Throughout my years at Canterbury and the University of Kent, I have enjoyed the friendship and help of many people to whom I must express my acknowledgements.

First, I would like to thank my supervisor Professor Roger Vickerman for his guidance and help during the whole period of my research. His contribution to my work is valuable. I would also like to thank Dr Maria Garcia Alonso for useful comments, especially, at the final stage of my PhD submission. Special thanks are also owed to the examiners of the thesis Professor Rod Falvey from the University of Nottingham and Professor Hans-Martin Krolzig from the University of Kent.

It would have been a crucial omission if I did not express my thanks to the group of participants in the internal Kent seminar series that provided me with insightful comments and suggestions for improving the output of my research. I am grateful to the officers of the National Statistical Service of Greece (NSSG), for providing me the data used mainly in the empirical part of the second chapter. In addition, I am grateful to Kostas Aivalis, Chief Economist of ICAP, who offered me the financial directory of the Greek manufacturing sector over the last fifteen years. I have used this data set in Chapter 4. I want to thank my friend and former Course Leader Dr Kostas Tsekouras from the University of Patras. His motivation and support during my undergraduate studies played a crucial role in deciding to pursue a PhD.

This thesis would not have been possible without Elpida, whose presence and love have been the most effective solution to any problem I encountered till the completion of my PhD thesis. Our relationship has been an integral part of my research life. I return to her my love with all my heart. I would also like to thank my officemate and good friend Abdallah Nasseredine whose company, during the years of our research, has been very cheerful. In this occasion, my thanks are extended to the Members of staff and the PhD group of the Department of Economics at the University of Kent that

offered me a very dynamic environment to carry out my research. Finally, I would like to express my love and special thanks to my sister Rania and my brother Nikos but the biggest gratitude is owed to my mother Irene and my father Theodore whose support is more than valuable since I was born.

Chapter 1

Competitiveness Productivity and Trade: An overview

1.1 Defining Competitiveness

While competitiveness dominates most of the debates in public policy making, there is no precise and acknowledged definition of competitiveness in economic theory. Economic analysts and politicians use the term in a rather broad way. Obviously, their understanding of the term “competitiveness” is based on different grounds signifying somehow the amorphous nature of the term and the variety of its applications. These characteristics imply that any effort made to analyse the sources of competitiveness should include many different aspects. This task is the principal objective of the present thesis.

The study is divided in three chapters. Each chapter investigates different approaches that are implicitly or explicitly associated with competitiveness. Before outlining the main approaches used in the present thesis in analysing issues with regard to competitiveness, it is imperative to describe what is meant by competitiveness. One could argue that competitiveness is not a pure economic term since in any individual activity, people try to compete in a sense that they try to be better than their rivals (Fagerberg (1996)). In management jargon, to be competitive is something that is reasonable but from an economic theory point of view, the term of competitiveness is vague and sometimes causes confusions and disagreements among members of the economic profession¹. Strictly speaking, the term “competitiveness” becomes meaningful only if one can determine precisely the basis or the source of the comparative advantage incorporating within this definition the fundamental principles of economic theory.

¹Two best-seller books by Crichton (1992) and Thurow (1992) address various issues of competitiveness with special emphasis to the role of US in the world economy. Krugman (1993), in a short note claims that arguments mentioned in the above books are misleading obsessions about international trade and in many cases these arguments are not consistent with the fundamental principles of economics.

At the national level, a competitive firm succeeds in gaining a larger share of the market, at the international level a competitive firm undertakes activities in foreign countries and in the long-run succeeds in fostering their presence by gaining gradually a larger share in the export markets. Again, this is only a description of a competitive firm without suggesting what makes the firm to expand its activities. Economic researchers are therefore free to determine in their own way the adequate characteristics of the term “competitiveness”. This is the starting point of a very crucial debate about the importance of the term “competitiveness”.

The economic agenda of political parties consists of various reports and policies targeting to improve a country’s “national competitiveness”. Apart from the standard issue referred to whether these policies are effective for improving competitiveness, whatever its precise definition is, there is another more vital issue to academics about the validity of the concept “national competitiveness”. Wolff and Dollar (1993) argue that the definition of competitiveness at the country level is not meaningful because there are two main controversies with the term “competitiveness” at the macroeconomic level. Competitiveness at the national level is associated with power and dominance of a country upon other countries but such an approach is incompatible to the ideas of budget constraint, production possibility frontier and cost comparative advantage. A country cannot be competitive in the production of every good but differences in the structure of production and a number of historical and political idiosyncratic factors determine to some extent the areas of competitiveness. The second controversy with the use of the term “national competitiveness” is associated with the mainstream belief that competitiveness can be easily promoted through effective currency devaluations.

For Wolff and Dollar (1993), these considerations are rather mis-specified. Especially, a weak currency policy has been employed by developing countries and, undoubtedly, it brings some positive effects in the short-run. However, it will be an illusion if developing countries design their policy of strengthening competitiveness exclusively with such temporary tools (Özçelik and Taymaz (2004)). A sustainable competitiveness in the long-run should be relied on more profound economic mechanisms.

Some of these mechanisms are highlighted in this introductory chapter and they are analysed more systematically in the next chapters of the thesis.

At the micro level, the term “competitiveness” is clearly more meaningful. Reinert (1995) provides a standard definition to represent a competitive firm. The latter is a firm that has the capacity to grow and make profits in the marketplace. It is difficult to give a meaningful content of the second characteristic at the national level. Porter (1990), states clearly that a meaningful definition of competitiveness should explicitly refer to productivity. This approach seems to be rather functional since it allows to link productivity of micro-units (i.e. firms or industries) to productivity performance of nations. Although, Porter (1990) introduces the notion of productivity in the analysis of competitiveness, from an economic point of view his methodology presents two notable weaknesses. First, Porter’s (1990) model does not allow us to quantify easily and accurately the determinants of competitiveness.² In Porter’s “diamond” model, competitiveness and thus productivity can be derived from innovative activity, which is promoted under four certain conditions (i.e. the four elements of the “diamond”). One of these conditions, in Porter’s words, is “sophisticated customers”. Nonetheless, it is difficult to measure sophisticated demand without referring explicitly to income levels. In such a case, the direction of causality is unclear as one cannot distinguish whether higher income can lead to greater competitiveness or vice versa. Second, Porter’s model does not yield a theory of comparative advantage in the typical economic way as it offers only *post hoc* explanations and not clear predictions for the nature of comparative advantage across countries (Lall (2001)).

Hughes’s (1993) definition of competitiveness recognises the vital role of either absolute or relative efficiency. Along with efficiency, Hughes (1993) pays attention to a set of more general factors that affect international competitiveness. These factors highlight the importance of various firm

² Porter’s model of competitive advantage is not associated with any of the propositions of the Heckscher-Ohlin model. In his approach competitive advantage is associated with a firm’s effort to develop new products and methods of production. An empirical assessment of such a model is a-priori problematic as it is not based on rigorous and clarified arguments.

characteristics in a firm's competitiveness in a way far beyond the conventional path of productivity. From this perspective, a firm can improve its competitiveness by reforming the organisational scheme, by changing the ownership status and by promoting innovation. According to Hughes (1993), these features are key ingredients in understanding the puzzle of competitiveness. However, one can naturally claim that these features are not independent from productivity, since the latter is a concept much wider than structural changes per se. To some extent productivity improvements already reflect successful changes in the aforementioned structural reforms.

Summarising the previous discussion, throughout the present thesis, competitiveness is defined as *the ability to maintain high rates of productivity growth*. This definition of competitiveness has two distinct advantages. First, in such a context the analysis of competitiveness can be meaningful in economic research because it can provide us with clear predictions whose empirical validity can be tested. Second, associating the notion of competitiveness with productivity allows us to link appropriately efficient economic performance with high levels of income and living standards.³

1.2 Competitiveness and Export Behaviour

The debate on competitiveness dominates the EU economic policy agenda. The term of competitiveness is of special interest for EU member states from two different angles. One of the fundamental targets of the EU since its constitution is to create wealth for its member states within a set of common policies and under a tight path of cohesion. This implies that the overall strategy of EU is to promote policies that improve productivity within member states and then to ensure a fair income distribution of these productivity gains. The second aspect of interest refers to the fact that the EU experienced a slowdown in productivity growth compared to US during 1990s. O' Mahony and Van Aark (2003) suggest that it is difficult to understand the decrease in competitiveness without being able

³ This view is not universally accepted since Reinert (1995) notes that national wealth is not always associated with increases in national productivity.

to understand the sources of the productivity gap between EU and US. To the extent that improvements in competitiveness at the micro level increase competitiveness at the national level then factors leading to aggregate productivity slowdown can be easily investigated using disaggregate evidence from firms or industries.

At the micro level, the competitiveness path implies that the more productive a firm is the larger the sales share it gains in the marketplace. With minor modifications, this causal link can be applied to associate successful performance with commercial expansion in international markets. If a domestic producer seeks to serve international markets then it has to face a number of additional impediments such as a large number of suppliers for a particular product, high demand standards, additional costs of establishing selling networks abroad etc. A firm that is able to fulfil these international standards is without doubt a competitive firm and thus it can increase exports. However, to link directly productivity with exports at the national level is a plain scenario that ignores the deeper reasons of the export expansion. For instance, the export boom of US in middle 1980s and the beginning of 1990s, is not justified by a similar growth in real GDP. The fact that movements in aggregate exports do not resemble movements in GDP growth does not cast doubt whether productivity is associated with more exports. Rather, it raises concerns whether the use of aggregate data is the appropriate method to identify which sector within the economy plays the most important role on this export boom. In this case, Bernard and Jensen (2004a) exploit a different hypothesis focusing on plant-level data in order to explore the US export boom for the period 1980-1990. Given that not all sectors of the economy have the same contribution to the increase of aggregate exports, with the above strategy we can have a clear indication about which groups of industries or firms have the largest share in the overall exports increase. The use of disaggregate data permits us to assess whether industries (or firms) with particular characteristics have more significant contribution to the overall exports expansion. These characteristics might attribute the behaviour of domestic units to undertake the appropriate restructuring efforts in promoting productivity or might reflect other efforts towards a more successful

export performance. In brief, the above discussion makes transparent that in order to acquire a clear picture of the drivers of export activity, it is more appropriate to use more disaggregate evidence. With these considerations in mind, the first core question of the thesis is as follows:

Is cost competitiveness a factor that drives manufacturing exports?

The above empirical question is analysed with particular reference to Greek manufacturing industries. To make the analysis comprehensive, several issues need further clarification regarding the competitiveness-exports nexus. The key feature of a competitive industry is the cost-minimising behaviour. The ability of an industry to reduce costs can be derived from various sources such as organisational skills, market structure, ownership status of the firms operating within the industry etc. Whatever the factors of cost effectiveness are, the latter generates substantial gains allowing firms to expand activities. This type of gains may represent improvements in both allocative and economic efficiency allowing industries to devote resources for establishing commercial networks in international markets. A similar link between cost efficiency and export activity implies that efficiency gains can be “passed through” into prices improving the price competitiveness of goods exported.

Another important issue about export performance is to identify sources that affect competitiveness but they are not related to cost behaviour of industries. This proposition is based on Kaldor’s (1978) finding that international competitiveness of industries is also determined by factors of non-price competitiveness. Such an argument indicates that a complete investigation of the determinants of exports should also include non-price factors such as the quality of products exported⁴. The evidence from this case study can find plausible applications in other EU countries especially in those sharing similar characteristics with Greece.

⁴ A precise measurement of the quality level of a product is almost impossible. Instead, some proxies are applied to indicate the qualitative characteristics of the goods produced.

1.3 Competitiveness and International Specialisation

The above discussion suggests that the term “competitiveness” is more meaningful when applied to industry rather than to country level analysis. However, there are analysts such as Fagerberg (1996), who argues that competitiveness is by definition a relative term with applications in many aspects of the social life and thus there is no compelling reason against the use of the term at the national level. On this basis, national competitiveness can be applied to describe some trends in the total economy but one should be careful when draws strong with respect to national competitiveness. What seems to be ignored by analysts that favour the use of term “national competitiveness” is that an improvement in a country’s productivity performance does not necessarily mean that all industries contribute to this improvement equally. In the same line of argument, increases in the aggregate level of a country’s productivity do not imply that the country becomes a net exporter in all industries. A statement that can be done with relative certainty is that a country with relatively high levels of aggregate competitiveness has a relatively higher level of per capita income (Dollar and Wolff, 1993, p.4); however, further implications concerning country’s trade pattern leads to mis-specified arguments.

The realistic notion is that nations have productivity superiority on different industries and thus there is a potential for international specialisation. Table (1.1) displays an index of labour productivity for a selected group of OECD countries for seven manufacturing industries. While the levels of total manufacturing do not present substantial differences across countries, there are noticeable disparities across individual industries.

France is clearly more productive than Denmark in machinery, while the opposite is true in chemicals. Japan is more productive than Italy in machinery while Italy is more productive in food industry. A similar pattern is revealed between Denmark and Norway. The level of labour productivity in total manufacturing is almost identical but Denmark is more productive in food industry than

Norway while the reverse is true in paper industry. Comparisons for any other pair of countries indicate similar patterns.

When attempting to link the levels of labour productivity with the exports-imports ratio, the patterns are not always clear. For example, French labour productivity in motor vehicles is the highest of the sample and this is accompanied by a relatively high export-imports ratio in this industry. Nonetheless, this is not the case for the German vehicles industry, which has a very high exports-imports ratio but the level of labour productivity is relatively low compared to other industries. Regardless of whether superiority in labour productivity matches export comparative advantage in the corresponding industry, table (1.1) indicates that looking at the aggregate level is difficult to draw clear conclusions at least as far as labour productivity is concerned. There are countries, which are productivity leaders in some industries while in some others fall behind. Across countries the measure of labour productivity of aggregate manufacturing does not indicate marked differences supporting the argument that the use of competitiveness at the national level generates misleading results.

Table 1.1 Labour Productivity and Export-Import Ratio for Six OECD Countries 1991-2003

Industry	Export -Import Ratio					
	Denmark	France	Germany	Italy	Japan	Norway
Chemicals	107	120	152	63	117	103
Motor Vehicles	40	129	201	77	935	NA
Basic Metals	67	100	120	91	136	139
Food	240	135	85	70	6	172
Machinery	108	95	145	149	317	42
Textiles	77	71	58	245	25	13
Paper	57	75	115	82	61	97
Total Manufacturing	107	106	128	123	175	73
Labour Productivity Indices (LPI)						
Chemicals	125	111	102	99	107	129
Motor Vehicles	119	126	89	104	NA	NA
Basic Metals	102	101	100	95	102	127
Food	104	96	95	101	90	98
Machinery	101	117	104	96	119	95
Textiles	111	108	106	97	101	107
Paper	102	105	106	101	101	112
Total Manufacturing	105	104	102	98	108	102

Notes:

Data obtained from OECD STAN Indicators Database. The figures refer to average values over the period 1991-2003. Labour productivity is defined as the ratio of value added volumes to number of workers engaged. LPI uses 1995 as reference year. The export-import ratios is the value of exports over imports times 100%. The values of exports and imports are calculated in US current prices. Indication NA means that this figure is not available

The fact that countries have productivity superiority in different industries represents the importance of comparative advantage. Countries have different profiles and their comparative advantage is based on different economic activities. France is not competitive in producing textiles in relation to Italy while it is more competitive than Italy in producing chemicals. In this case, international trade theory suggests that France has a comparative advantage in chemicals while Italy has a comparative advantage in textiles and thus they should specialise accordingly. Krugman (1994) one of the most prominent sceptics of the term “competitiveness” supports that any discussion about structural competitiveness repudiates the principles of international trade theory. The key element underlying the conflict between the analysis of competitiveness and the principles of the neoclassical trade theory is whether countries should prefer specialisation in specific sectors. The latter

consideration implies that an effective competitiveness strategy distinguishes between high and low value sectors recognising the different importance of economic activities.

Reinert (1995) accepts as valid the distinction in low and high value sectors recognising that the neoclassical trade model is founded on simplistic assumptions that do not always reflect the conditions of the real world. These failures- to name some imperfect competition, heterogenous products, non-constant returns to scale, and externalities - prevent from factor price equalisation. Under this framework, imperfections are crucial drivers of competitiveness indicating the importance of a competitiveness strategy at the national level (Lall (2001)). Krugman (1993) considers the division between low and high value sectors as a misconception derived from what he calls “pop internationalism”. From a neoclassical point of view, what really matters are the benefits of specialisation per se without much attention to which product the country produces (Wolff and Dollar, 1993, p.15). Trade is not a strategic war and even more is not a conflict among countries for which of them will specialise in the right high value sector.

The neoclassical perspective implies that imports are equally important as exports since they help countries to consume goods that they cannot produce themselves efficiently. On this basis, trade is a mutually beneficial exchange and as such, it provides valuable gains to any party involved. Countries have different production structures and thus different patterns of specialisation. These disparities generate the need for international trade but there is no a formal underpinning to classify countries into those, which specialise in high-value sectors and those, which specialise in low-value sectors⁵. Consequently, the second core question of the thesis is formulated as:

⁵ Even if there are no “magic” sectors in the economy, the analysis of competitiveness has a central role on the neoclassical model. When some of the assumptions of the neoclassical model fail then the debate of competitiveness in a country should focus on the type of changes required in order to strengthen dynamic comparative advantage. In such a case, the main objective of economic policy is to promote the appropriate structural reforms assisting industries to increase productivity and thus maintaining their comparative advantage in the long-run.

Which forces determine the international pattern of specialization?

The strategy followed in answering this question is based on the economic priors of the neoclassical model. More precisely, the theoretical framework used to investigate the sources of specialization builds upon the propositions of the Heckscher-Ohlin (H-O) and Ricardian models of comparative advantage.

The H-O model stresses on the impact of national relative endowments on the industrial structure. This approach is based on a general equilibrium framework, which investigates why nations specialize in specific economic activities and why they are not excelling in all of them⁶. The character of the model is that the mixes of factor supplies at the aggregate level dictate the pattern of specialization at the industry level. The H-O theory relies on the strict assumptions of factor price equalization (FPE) and common technology across countries. Trade economists have devoted particular effort to understand whether these assumptions are compatible to real facts. There is somehow a clear indication that FPE fails in real conditions⁷ but still the overall predictions of the model provide useful insights for the pattern of specialization. On the other hand, the Ricardian model draws special attention to unit labour costs. In the simplest version of the model, comparative advantage is determined by differences in the relative unit labour costs of production. As pointed out before the productivity of labour in particular industries differs across countries; hence, the country with the relatively higher productivity acquires the comparative advantage in this industry.

For many years, these models have been the most popular workhorses in the analysis of comparative advantage. However, there is little work done regarding the linkages between the two theories. A legitimate question is whether H-O and Ricardian are fighting theories or propositions from

⁶ The main implication of this general equilibrium framework is the Rybczynski effect, which states that increases in a factor endowment increases the output share of an industry that uses this factor intensively.

⁷ This view converges to the opinion of Reinert (1995) that the neoclassical model ignores the imperfections of the economic structure. As already mentioned in footnote 5, these imperfections can lead to competitiveness.

both models can act in a joint model. Some recent developments in the research agenda of international trade have attempted to treat these theories as complementary despite the fact that these theories rely on contradictory assumptions.⁸

Let us illustrate an example to make transparent why H-O and Ricardian forces can be accommodated in the same model. China is specialized in textiles and the Netherlands is specialized in TVs. China is relatively more productive than the Netherlands in textiles without necessarily possessing a superior technology. Textiles industry is traditionally labour intensive and China is abundant in this factor. On the other hand, the Netherlands is relatively worse endowed in this factor and despite that it is feasible to produce the same amount of output as China, this does constitute an optimal allocation of the resources. This type of specialization pattern is driven by differences in relative factor abundance and thus it is consistent with the propositions of the H-O model. However, this pattern is not compatible to any pair of countries and their corresponding comparative advantage. US have the largest share of exports in aircrafts while Japan has the largest exports share in electronics and telecommunications products. Both goods require high levels of human and physical capital indicating that there is little space for a frame of relative factor differences to predict this pattern of specialization. One of the most prominent explanations why US produces aircrafts and Japan produces electronics is that these countries have obtained the essential technological know-how in these industries permitting them to gain the highest share of sales in the global markets.

A direct measure of a country's technological expertise in a particular industry is almost infeasible. The common regularity is to approximate technological differences using an index number approach for the measurement of Total Factor Productivity (TFP). TFP is the Ricardian equivalent of unit labour costs in a multi-factor context. In general, technological superiority can be viewed from many different aspects. Technological superiority is both the ability to innovate by differentiating

⁸ H-O considers that factors of production have the same productivity across countries, thus what a country produces depends on the relative factor endowments. In contrast, the central theme in the Ricardian theory is productivity differences of the labour factor.

products (product innovation) and by using new methods (process innovation) that improve productive efficiency. Unfortunately, the present TFP measurement is rooted in a Solow residual approach making no distinction whether the technological advantage of countries relies on their ability to differentiate the qualitative characteristics of the product or to reduce costs of production. Particular emphasis is given to the second process since this implies a more direct link between production, cost and price. In terms of the US-Japan example, Japan's comparative advantage in electronics is associated with relatively higher productivity or equivalently lower cost of production and thus relatively lower international price of the product.

1.4 Economic Performance and Productivity Growth

As pointed out above, one of the most prominent sources of competitiveness and international specialization is productivity. The special characteristic of productivity is that it relates efficiency gains and the level of prosperity in a country. Prosperity is not inherited instead it is developed via the appropriate economic decisions of the agents involved in the overall economic process such as state, firms, households, legitimacy frame etc. The above considerations need a more systematic analysis, which is the departure point of the third question addressed in the thesis:

Which factors drive TFP Growth?

Dollar and Wolff (1993, p.49-50) note that there is substantial productivity convergence at the aggregate level between 1960 and 1980. Aggregate productivity convergence does not necessarily imply that there is also convergence at the industry level. Harrigan (1999) reveals remarkable industry TFP disparities for a big number of OECD countries. The debatable question in the productivity differences agenda is what makes some industries to grow faster than others. Among factors that gain

special attention are the level of investment and the outward orientation of the industry. Investment comprises of three types of expenditure that all play a key role in promoting productivity. These are: (a) investment in physical capital that ensures the use of more sophisticated capital goods improving the level of technological capabilities, (b) investment in human capital that upgrades the skills and the abilities of the labour force leading to higher levels of labour productivity and (c) investment in Research and Development (R&D) that leads to new production techniques improving efficiency and reducing costs. Undoubtedly, not all the firms in an industry conduct substantial R&D but knowledge spillovers are likely to be present giving the opportunity to non R&D oriented sectors to get benefits from the innovative activity of the others.

The outward orientation of the industry mainly refers to the industry's trade involvement. In the first phase a relatively trade oriented industry has the opportunity to exploit benefits from contacts with international best practices. In the second phase, the diffusion of knowledge allows non-trade oriented counterparts to familiarize themselves with the new techniques leading thus to a boost of industry's overall productivity. These mechanisms are the most profound conduits of productivity growth; however, there are various factors that affect productivity performance, to name some, the presence of multinationals in the domestic market (internationalization of the market), the degree of competition and labour and product market rigidities (institutional factors).

The examination of the sources of productivity growth is focused on Greece. Evidence from analysing one country has the disadvantage that the results produced refer only to one country and thus more general conclusions are difficult to be drawn. This drawback is limited, if one takes into account that data from one country ensures a higher degree of homogeneity with less measurement errors. Greece is an interesting case as it is an established member of EU (also of EMU) but from many other aspects, it remains a peripheral economy. This feature is of particular importance since it implies a specific analytical framework through which one can investigate the sources of productivity growth. In the present thesis, the analysis is conducted within a framework of convergence between Greece and

German manufacturing. In a gradually integrating European environment with less barriers and restrictions, countries that have fallen behind like Greece have a great opportunity to borrow technology from advanced countries of EU. The potential of technology transfer from a “technological frontier” to a “technological non-frontier” country and the profound forces of R&D and trade serve as the main vehicles in investigating the sources of TFP growth in Greece.

Chapter 2

The Determinants of Exports in the Greek Manufacturing Sector

2.1 Introduction

The gradual removal of various trade barriers, especially within the EU has undoubtedly generated an attractive environment for member-states to expand their export activity. There are many unexplored issues in relation to export performance of nations and thus trade economists have devoted great effort in explaining the sources of export flows. The focus on the sources of export performance is attributed to many facts. First, economists seek to evaluate the propositions of trade theory with the use of actual data. Second, and more importantly, is that trade and more particularly export data are now easily available in various classifications. The availability of data offers to researchers the opportunity to test empirically many different hypotheses. The findings from analysing export performance can have many valuable applications in policy-making. One of them is associated with the nature of gains derived from a substantial export activity. The main debate in the literature of export performance is whether exporting can generate important learning benefits from international spillovers in technological knowledge and ideas. The benefits provided by international spillovers can help less developed countries to grow faster especially, those that they do not have their own resources to invest in new technology.

The link between trade and growth has various aspects and one of them is focused on the export-led-growth hypothesis (see among others, Jung and Marshall (1985), Xu (1996), Romer and Frankel (1999), Panas and Vamvoukas (2002)).⁹ These studies investigate the export-led-growth hypothesis from a country level scope, while the increased availability of reliable and consistent micro-level data has allowed to expand the investigation of the exporting-productivity nexus at the firm level (see among others, Bernard and Jensen (1999a, 1999b, 2004b), Roberts and Tybout (1997), Clerides et al.(1998) and Greenaway and Kneller (2004)). Nonetheless, the analysis of whether exporting affects economic performance is the second phase of the whole puzzle.

⁹ The impact of trade on growth is systematically analysed in chapter four of the present thesis.

Before assessing whether and to what extent export activity stimulates growth, a systematic analysis is necessary to identify the driving forces of export performance. The present chapter undertakes this task by investigating empirically the set of factors that drive export performance. Many models in the literature are designed to implement this task but their nature is based on different conceptual ideas, which implies that there is not a unique model that fits all the cases (King (1997)). A traditional approach in applied trade analysis focuses on the demand side of trade flows. The demand side models consist of two key variables, the ratio of relative prices and a measure of economic activity in the foreign country. The main drawback of this type of models is that they rely on the assumption that there is an infinite elasticity of export supply.

This assumption is problematic (Magee (1975)) and it is more reasonable to assume that the demand for exports is perfectly elastic in the short run at least for the case of a small open economy. In such a case, there is a need for a more systematic treatment of the supply-side determinants of exports. The demand side models encounter two main problems. The first problem arises, as one might understand from the previous argument, from the omitted-variable bias. The second is that relative prices are not exogenously determined and thus the model cannot be estimated using a standard OLS technique. Some researchers (see O' Neill and Ross (1994), among others) control for endogeneity problems by applying a simultaneous equation model in which the demand and the supply models are estimated within the same system.

The present study favours an eclectic approach in explaining the determinants of export performance in which forces of the demand and the supply side are included in the same function of exports. This is known in the associated literature as the *Export Determination Model* (Goldar (1989)).¹⁰

The export determination model mainly includes components of price and non-price competitiveness as well as indicators of the domestic market conditions and the foreign demand.

¹⁰ Apart from the demand side, the simultaneous equations and the export determination models, there is another type of model used to explain export behaviour, namely the two-regime model (Batchelor (1977)). King (1997) provides an extensive literature review of these models along with the crucial findings revealed from the use of each of the above approaches.

Chapter 1 states that there is a strong link between exports and competitiveness. The present chapter addresses the issue of competitiveness more analytically by constructing a measure of productivity that stands as a measure of cost competitiveness. Given that a productivity measure is one of the most articulate proxies of competitiveness, there is a need for a systematic investigation for the impact of productivity on export performance.

The rationale for using productivity as a determinant of exports reflects various factors. The most prominent one is that productivity improvements are associated with an upgrade of industry's *x*-efficiency level. Higher *x*-efficiency level indicates that industry becomes more effective in the way it uses the available resources (Leibenstein (1966)). The initial formulation of the *x*-efficiency theory emphasises to non-allocative improvements highlighting successful changes in the market structure and the organisational practices. Nonetheless, this type of changes can implicitly have a drastic impact on the allocation of resources. Taking the latter consideration a step further, one can imply that *x*-efficiency gains can derive from a wide range of factors, such as technical progress, exploitation of scale economies and positive changes in the institutional framework. These structural changes at the industry level are likely to have both direct and indirect impacts on export performance. Since exporting is accompanied with an extra burden of sunk costs, improvements in *x*-efficiency imply that industry has the resources required to expand commercial activities abroad.¹¹ A more indirect effect is that gains in *x*-efficiency performance can “pass through” to commodity prices thus, fostering the industry's ability to compete successfully in international markets. Consequently, the productivity measurement, to some degree, can serve as a measure of relative prices within the context of an export determination model.

¹¹ A similar argument is found in studies that use firm level evidence to investigate the exporting-productivity nexus. The underlying story in this bulk of literature is that firms below a critical threshold of productivity do not enter the export market because the prospective profits do not compensate the additional costs. Dixit (1989), Baldwin and Krugman (1989), and Roberts and Tybout (1997) formalise the above idea in a theoretical model of entry and exit decision under conditions of uncertainty. Empirically this hypothesis has been tested in a big number of studies with the application of data from a broad range of developed countries and has been proved valid (see among many others, Bernard and Jensen (1999a and 1999b), Greenaway *et al.*(2002), Bernard and Wagner (1997) and Castellani (2002)).

However, export activity is also affected by factors that determine the quality of goods traded rather than their cost of production. Kaldor (1978) is one of the first that points out the existence of these non-price competitiveness factors showing that movements in export growth and unit labour costs are in the same direction. This paradox (known as the Kaldor-Paradox) suggests that export behaviour is influenced by non-price factors representing the technological content of trade.

Price and technological factors of competitiveness take into account only the supply- side of trade. As already mentioned, there is a long tradition in the applied trade research that concentrates on the demand-side forces of export behaviour. Thirlwall (1979) makes a substantial contribution that analyses the prospects of growth and the demand side of trade. According to Thirlwall's model, the growth rate of a small open economy depends on the growth rate of international trade, on the changes in relative prices and on the ratio of the income elasticity of the demand for exports to that for imports. The implication of Thirlwall's model is that the higher the income elasticity of exports, relative to that for imports, the higher is the growth rate of the economy.

The above discussion highlights the main pillars upon which this study investigates the export determinants of the Greek manufacturing sector over a period of ten years. A major feature of the present paper is that the industry data are provided in a high level of disaggregation, which is not common in the export determination literature. However, a different degree of aggregation is also considered especially, when some variables are available only in a relatively aggregate form.¹²

The present study contributes to the existing literature from various aspects. Firstly, it provides evidence for Greece's export performance that has not attracted considerable attention. Exceptions are studies of Argyrou and Bazina (2004) and Skouras and Tsekouras (2005) but the aim of the present analysis differs substantially from the objectives of the above papers. Secondly, this study enriches the applied literature of export determination models, which is rather poor compared to evidence from other methodological approaches.¹³ Thirdly, the present study uses an

¹² For example, a smaller level of disaggregation is used when information is required for Greece's export partners.

¹³ Apart from Goldar (1989), who is the founder of the term "*Export Determination Model*", other studies that use a similar methodological approach are Riedel et al. (1984) and Anderton (1992).

index of Total Factor Productivity (TFP), which is a superior measure compared to Unit Labour Costs (ULC) that is routinely used in export studies to capture the effect of cost competitiveness. Finally, the present study offers evidence for the determinants of export behaviour at the industry level,¹⁴ using highly disaggregate data.

The remainder of the chapter is organised as follows. Section 2.2 discusses the determinants included in the *Export Determination Model*. Section 2.3 introduces essential information about Greece, which is the case study of this chapter. This part displays some stylised facts about the performance of Greek economy with particular emphasis to main events occurred during the period under study (i.e.1990s). This section also discusses issues related to the data sources. Section 2.4 defines the variables used in the empirical analysis. Section 2.5 presents the econometric specifications of the study and the results. Section 2.6 concludes summarising the findings of the study and highlighting some crucial caveats related to the present research.

2.2 Determinants of Export Behaviour

This section discusses the main determinants of export performance and the channels through which these determinants influence export activity. Apart from price competitiveness, the European Central Bank (2005) pays special attention to factors of non-price competitiveness. One provision states that: “[...] *for many European countries the relationship between exports and price competitiveness is weak, indicating that other factors, which are broadly defined as non-price competitiveness, may also play a role and need to be investigated when assessing export performance*”.

In brief, the present study builds the analysis of export determinants upon four pillars: (i) cost effectiveness, (ii) technological competitiveness, (iii) domestic market forces and (iv) foreign demand. The third group outlines how conditions in the domestic market can act as an incentive (or disincentive) for an industry’s export activity while the fourth group addresses the role of demand

¹⁴ Recent studies with industry level data refer to Bleaney and Wakelin. (1999), and Liu and Shu (2003). See Fagerberg (1996) for a review of the existing literature.

conditions in the destination country. The list of factors affecting export performance is not limited only to the above, admittedly, this list excludes factors that routinely considered as factors that play a role on export attitude. For instance, factors of structural competitiveness such as the degree of regulation in the product and labour market might affect exports, but their importance in the present framework is captured through the measurement of productivity. In a more general view, structural factors are likely to be crucial determinants of exports but only in a cross-country perspective, which is not the case in the present study which focuses on export behaviour of a particular country and so these structural effects are common to all industries.

2.2.1 Cost Competitiveness

Bernard and Jensen (2004a) suggest that two most dominant driving forces of export activity are changes in exchange rate and productivity. Both of these factors have substantial influence on export price competitiveness. Nonetheless, changes in these factors highlight different type of effects. Improvements in productivity reflect various reforms occurred at the industry level and can affect positively the industry's cost behaviour. On the other hand, exchange rate movements are associated with economy-wide events and indicate effective changes in the macroeconomic environment.

As far as the exchange rate policy is concerned, the natural question posed is whether relaxing “strong” currency policies can foster international competitiveness and thus boost exports. Regardless, whether currency depreciation generates the expected results, exchange rate movements do not reflect any successful restructuring effort at the industry level. Additionally, changes in exchange rate can affect exports of all manufacturing industries in the same direction, casting doubts about the usefulness of this indicator as a measurement of price competitiveness for industry level analysis. The present study clearly favours the scenario that sustainable export performance should be designed in a long-run horizon incorporating successful reforms in the industry's cost competitiveness.

An accurate measure of price competitiveness requires the use of data on export prices. This task is rather difficult due to the lack of reliable data on export prices. To overcome this constraint, we analyse the relationship between price competitiveness and export intensity employing a relatively broad measure of cost effectiveness. As mentioned before, this measure accounts for various types of structural changes that affect industry's cost performance and can be partly "passed through" into prices.

A common regularity in the literature of export performance and international competitiveness is the use of relative unit labour costs (RULC) as a measure of cost- competitiveness. This measure is viewed as rather functional since it includes information of three components, exchange rate, labour productivity and average wage. Van Reenen et al. (2001) assume that labour is the only factor that affects marginal cost since the reward to this factor varies substantially and is relatively immobile across countries. This consideration is appropriate when there is a lack of data for the other inputs of production. Conceptually, fixed capital assets are also immobile internationally and their prices differ substantially across countries. What really matters in the measurement of productivity is how intensively the factors of production are used in the production process. From this perspective, the most appropriate measure is a Total Factor Productivity (TFP) index that captures all the possible drivers of cost competitiveness.

2.2.2 Technological Competitiveness

Apart from the influence of costs on export performance, there are some new developments in applied international trade that indicate the importance of non-price competitiveness factors. Krugman (1979a, 1983) and Helpman and Grossman (1991) argue that high-growth countries face higher income elasticities for their exports, reflecting the increased variety of goods that these countries produce. The main characteristic of these goods is that they differ in quality and thus trade takes place under conditions of monopolistic competition. The increased variety of products is a

result of a successful innovation activity undertaken within countries. Posner (1961)¹⁵ addresses the role of innovation and technology on trade arguing that trade can be generated by new products and processes. A country that invents a new product has a technological lead over other countries. This country is able to export the good even though it does not possess a classical cost advantage. Trade occurs because it takes longer for the new good to be implemented in production abroad than the time needed for the new good to be demanded in other countries. Therefore, trade takes place because patents protect the innovation. On similar lines, technologically-advanced countries have the ability to export sophisticated goods under conditions of monopolistic competition. The main proposition of the neo-technology theory (see e.g. Soete (1987), Dosi (1988), Amendola et al. (1992) and Verspagen (1992)) is that exports are driven by the country's technological ability, which is reflected in that country's rate of innovation. Respectively, industries with substantial innovative activity are likely to be more export intensive than industries with poor technological records.

The measure and scope of technological competitiveness are two other issues that need further attention. Technological competitiveness is usually measured by R&D and patenting activity. However, the nature of the above measures is not always the same since technological improvements can lead to either product or process innovation. The former has a direct effect on the quality of the good exported while the latter is likely to affect only the efficiency of production without further implications on the features of the product. In such case, process innovation fosters cost rather than technological competitiveness. Moreover, it should be noted that not all industries have the same potential to undertake innovative activity. As Greenhalgh et al. (1994) and Ioannidis and Schreyer (1997) point out, innovative activity is a more important export determinant of medium and high technology industries than of low technology industries. Finally, one needs to take into account that the outcomes of the innovative activity- especially R&D-can be freely diffused across industries. Meliciani (2001) argues that technological linkages are mainly free flows

¹⁵ This theory is also known as the neo-technology theory of trade.

of knowledge spillovers and ideas. This argument implies that research effort undertaken by one firm can be easily imitated by another rival and thus there is no margin to formulate an export comparative advantage on the base of different R&D intensity.

2.2.3 Domestic Market Forces

Industry export behaviour is partially determined by demand conditions faced in the domestic market. Domestic demand is likely to influence an industry's capacity affecting thus its export attitude. If total demand (domestic plus exports) exceeds maximum output then domestic industries are biased towards domestic sales since they consider that potential revenue from export sales is less than this obtained by domestic sales. Therefore, industries firstly seek to fulfil the needs of the domestic market leaving relatively less resources for export commitment (Eaton et al. (1966), Winters (1974)). From an economic point of view, to consider exporting, as a residual activity is an arbitrary argument given that within the propositions of a perfectly competitive model the decision whether to export depends on the relative price at home and abroad (Riedel et al. (1984)). However, a number of imperfect circumstances¹⁶ such as the exploitation of monopolistic power in the domestic market lead producers to view exporting as a less profitable activity than by serving solely the home market.

Apart from the influence of domestic pressure on exports, domestic profitability is regarded to be another key characteristic of the domestic demand conditions. There are many different approaches regarding to the factors that affect domestic profitability. Raynold and Dunlevy (1998) point out that the conditions of internal demand have a cyclical character reflecting changes in fiscal policy. An expansionary fiscal policy increases demand for manufacturing products, raising thus, revenue of the domestic producers. The above approach is compatible to the post-Keynesian notion of profitability which indicates that a key driving factor of profitability is a change in aggregate

¹⁶ Monopolistic power in the domestic market is not the only disincentive against export performance. The existence of high transportation costs as well as a certain amount of sunk cost, required for the establishment of sales network abroad, can also act as exports disincentives.

demand (Tsaliki and Tsoulfidis (1998)).¹⁷ From a neoclassical point of view, the rate of profitability is determined by some particular characteristics of the domestic industry such as the degree of competition. According to this view, domestic profitability is likely to be the result of a price mark up policy representing the monopolistic behaviour of the domestic producers. Independently from the precise nature of the factors that affect domestic profitability, the influence of the latter variable on exports is expected to be negative. The reason is straightforward as increases in domestic profitability offer no incentives to domestic producers to develop substantial export activity. However, under certain circumstances it is likely that profitability and exports to move in the same direction, especially for industries that they are active in goods at early stages of the product cycle. Andersson (2001) notes that this type of industry faces fast growing demand in both the internal and the external market implying that industries with high rates of market growth increase the rates of profitability without necessarily experiencing monopolistic power in the domestic market. The main implication of this scenario is that high profitability enables industries to devote a fraction of their profits in order to develop commercial networks in international markets.

Note those industries, which face this pattern of demand, might increase profitability but inevitably, they face various risks since business performance becomes very sensitive to exogenous demand shocks. This environment does not allow for a stable long-run export attitude.

2.2.4 Exports and Foreign Demand

As mentioned in the introduction, the export determination model includes in the same export function both supply and demand-side variables. Price and non-price competitiveness factors as well as domestic market forces represent the supply-side of the model. The rationale for including demand side variables is compatible to the long tradition of applied trade studies and reflects the impact of economic activity of the destination countries on the demand for exports.

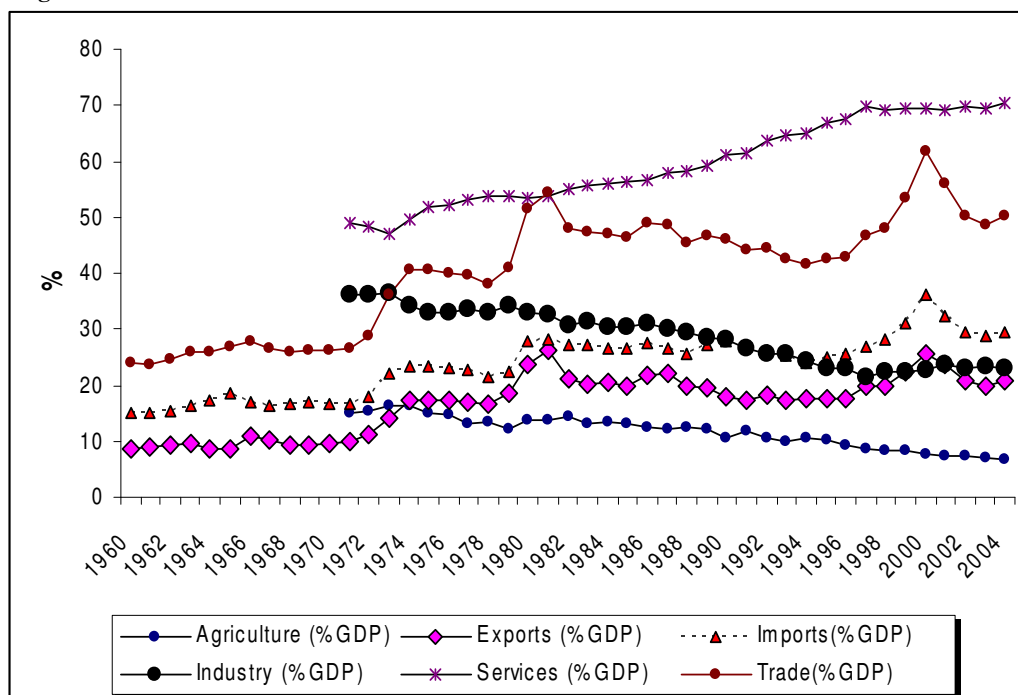
¹⁷ This study tests the validity and the explanatory power of different theories applied to explain the factors that affect the industry's profitability.

2.3 Case Study and Data Sources

2.3.1 An Overview of the Greek Economy

Trade orientation of the Greek economy has increased substantially in the last forty years. Figure (2.1) shows that trade share to total GDP was 24 % in 1960 and climbed to almost 50% by 2003. Both exports and imports components follow an upward trend over this period. Imports propensity is higher than export orientation in the Greek economy, although exports have steadily increased in the last forty years. The upward trend of Greece's trade orientation is attributable to various events that have occurred in the last forty years and have influenced positively free trade, especially with other European countries. Figure (2.1) also displays the value added shares of the three major sectors relative to GDP over the last forty-five years. In addition to the upward trend of the trade sector, there is a clear evidence for the increased importance of the services sector. As expected, agricultural sector experiences a steady decline, while the share of the industry sector (i.e. this includes the sub-sectors of manufacturing, construction, and energy) has slightly decreased in the last thirty years.

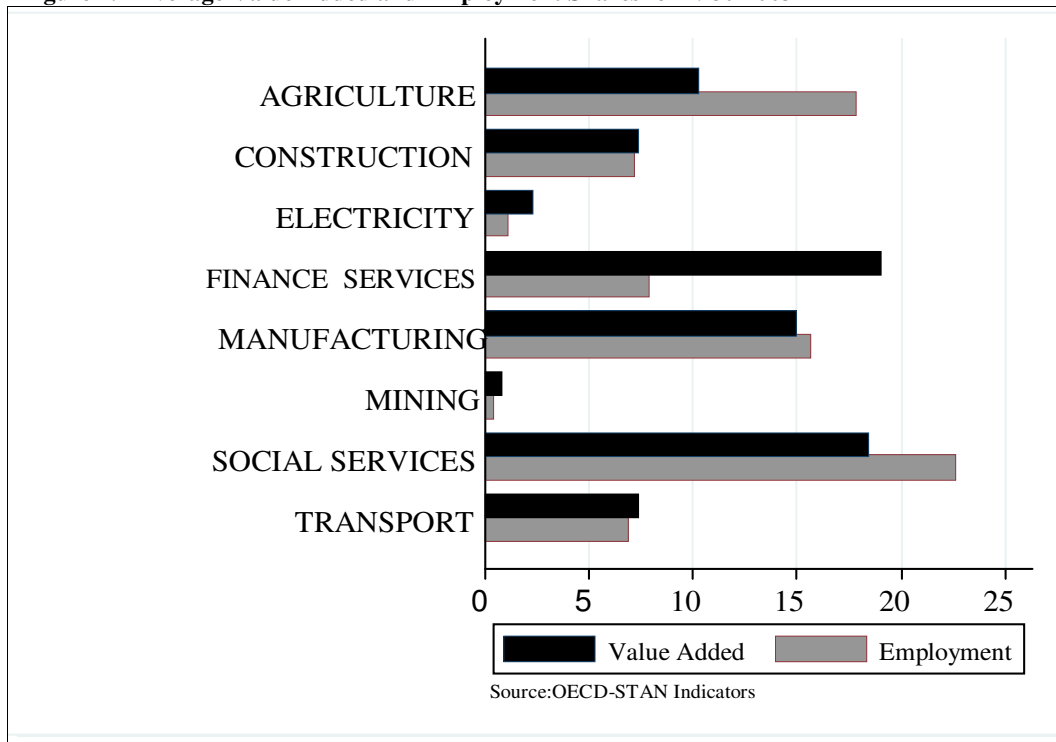
Figure 2.1 Time Trends of the Main Sectors



Notes: Data for the shares of industry and services' sectors to GDP start from 1971

A more detailed synopsis of the main production sectors of the Greek economy is displayed in Figure (2.2). Financial and Social services sectors possess the highest share of value added in the economy while the third most important contributor is the manufacturing sector. Figure (2.2) clearly suggests that for the period 1980–2003, agricultural, manufacturing and social services sectors are the principal sources of employment in the Greek economy.

Figure 2.2 Average Value Added and Employment Shares for 1980-2003



Before proceeding with a more detailed description of the data set used in the empirical analysis, it should be useful to highlight some key events that took place in the 1990s and might have a considerable effect on the export activity of the Greek manufacturing sector. In the middle of 1990s, Greek authorities started implementing various programmes of convergence in an attempt to stabilise the economy and to fulfil the Maastricht criteria.¹⁸ In this context, Greece reduced the budget deficit to below 2.5% of GDP and decreased inflation to around 5% by the end of 1998. Even so, Greece was not able to participate in EMU, which was formulated at the beginning of 1999. Greece did not manage to meet the specified fiscal policy criteria on time and thus price instability kept interest rates far above the corresponding rates of other member countries. To achieve price stability and to ensure that Greece would enter EMU in 2002, the Central Bank decided in March of 1998 to follow a currency devaluation policy, which introduced the Greek currency into the European Exchange Rate Mechanism (EERM). The new parity was determined as

¹⁸ Volz (2000) provides a detailed report for all the key events that occurred in Greece during 1990s which influenced the country's convergence programme before the accession to the EMU.

one ECU equals to 357 drachmae constituting deterioration by 12.3%. Apart from the macroeconomic aims served with this decision, currency devaluation is an a priori factor that affects competitiveness and trade. Studying Greek export performance in the 1990s presents an additional interest since it allows us to evaluate what macroeconomic events played a major role in the competitiveness of Greek manufacturing.

2.3.2 Data Sources

The current data set covers up to 93 (3-digit NACE)¹⁹ industries per annum from the whole spectrum of manufacturing activities. This set is an unpublished data set provided by the National Statistical Service of Greece (NSSG) and covers the period 1993–2002. All information provided is based on the Annual Industrial Survey of the NSSG,²⁰ which includes the manufacturing firms with more than 10 employees. The set of variables reported at the industry level are the number of firms, the number of employees, wages, output, value added, material expenditures, sales, investment and exports. The main aggregates are divided into various components. For example, the total investment spending is decomposed into investment in land, buildings, transport and machinery equipment. Similarly, purchases of intermediate inputs are classified into those for energy and raw materials. Labour costs include salaries and wages plus social security costs paid from employers.²¹

The information about the production inputs permits us to construct a four-input index of TFP, which is of particular interest in the analysis of export performance. Given that in the short run labour and capital are relatively the most fixed inputs of production, it is useful to know how variations in the relatively less-fixed inputs affect industries' efficiency and thus their export behaviour.

The fact that this study applies 3-digit industry level data contradicts the standard approach of other studies that analyse export performance using evidence either from 2-digit industry (Riedel et

¹⁹ NACE stands for the acronyms of the French phrase *Nomenclature statistique des Activités économiques dans la Communauté Européenne* (Statistical Classification of economic activities in European Community). Appendix A2.1 shows the 2-digit NACE industrial classification.

²⁰ The web link of the Greek Statistical Bureau is www.statistics.gr

²¹ Appendix A2.2 summarizes the data sources of the chapter.

al. (1984)) or data from a single industry (or product) (Goldar (1989) and Tsekouras and Skouras (2005)). A relatively high degree of data disaggregation reduces effectively the potential aggregation shortcomings. Although, aggregation bias is always likely to exist as long as the analysis uses industry and not firm or plant level data. A limitation of the present data set is that it covers a relatively short time span, which prevents from a more systematic analysis of export dynamics.

A trend of Greece's manufacturing export performance is shown in Figure (2.3) Two measures of export performance are used, the growth rate of exports, and the export ratio, that is exports over total sales. On average, the Greek manufacturing sector sells abroad about 21% of its sales; this share has increased steadily until 2000 while there is a small decline in the subsequent years.

Figure 2.3 Output and Exports of the Greek Manufacturing Sector

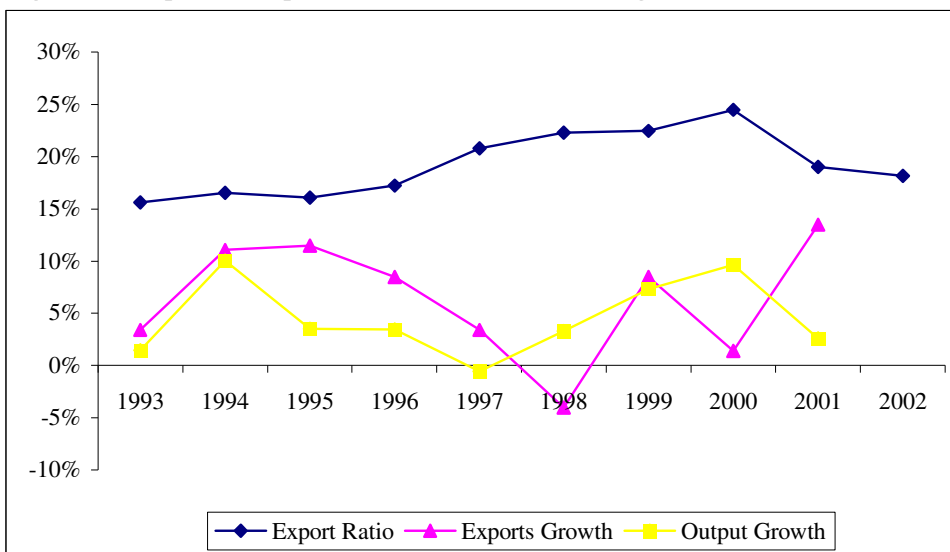


Figure (2.3) also displays the trends in average output and export growth. On average, exports and output grow by 6,3% and 4,4%, respectively. As expected, export and output growth rates follow a more volatile behaviour. From this preliminary evidence is difficult to obtain a clue whether exports and output are correlated as fluctuations their respective growth rates follow a similar pattern only until 1997. Table (2.1) displays growth rates of other industry variables. The

basic message from this table is that all variables experience a positive growth rate in the period under study.

Table 2.1 Growth Rates of Main Industry Variables

Year	Exports	Output	Value Added	Total Investment in Tangible Goods	Total Expenditure in Intermediate Inputs	Sales	Wages
1994	0.034	0.015	0.022	0.245	0.051	0.038	0.057
1995	0.111	0.100	0.051	0.372	0.167	-0.077	0.088
1996	0.115	0.035	0.076	0.334	0.017	0.052	0.070
1997	0.085	0.035	0.074	0.140	0.067	0.178	0.072
1998	0.034	-0.006	0.019	0.563	0.058	0.129	0.064
1999	-0.040	0.033	0.087	0.372	0.017	0.003	0.034
2000	0.085	0.073	0.022	0.644	0.200	0.127	0.091
2001	0.014	0.096	0.100	0.243	0.075	-0.137	0.058
2002	0.135	0.026	0.061	0.097	-0.011	-0.162	0.059
Average Growth Rate per annum	0.063	0.045	0.056	0.338	0.072	0.021	0.066

Notes:

Growth rates have been calculated after converting figures into 2000 constant prices. Investment in tangible goods excludes investment in machinery

2.4 Definition of Variables

As the central theme of the present chapter is to analyse whether changes in productivity affects export activity, it is crucial to show how the productivity variable is calculated. This section implements this exercise as well as discussing issues regarding the definition of other variables used in the econometric analysis. Tables A2.3 and A2.4 in Appendix A display summary statistics and pairwise correlation, respectively for the variables used in the chapter.

2.4.1 Modelling Productivity

The productivity index constitutes a close approximation of the Divisia index and derives from an underlying translog production function. The production model uses the inputs of labour (L), energy (E), raw materials (M) and capital (K). Given that the production model uses four-input model and differs from the standard two-input function, it is more appropriate to consider as an output measure gross output rather than value added (Higón (2004)). The model relies on the assumption that input markets are perfectly competitive and the production process is subject to constant returns to scale. The latter assumption implies that the sum of input shares is equal to one. After denoting the basic settings of the model, a general formulation of the production function is:

$$Y_{i,t} = A_{i,t} L_{i,t}^{\alpha} E_{i,t}^{\beta} M_{i,t}^{\gamma} K_{i,t}^{1-\alpha-\beta-\gamma} \quad (2.1)$$

Empirically A represents Total factor Productivity (TFP) and can be measured by using a Divisia index approach (Jorgenson and Griliches (1967)).²² Solving (2.1) for A (i.e. the industry subscript i is suppressed hereafter for simplicity) and taking logarithms, the following expression is obtained:

$$\ln A_t = \ln Y_t - \alpha \ln L_t - \beta \ln E_t - \gamma \ln M_t - (1 - \alpha - \beta - \gamma) \ln K_t \quad (2.2)$$

Differentiating (2.2) with respect to time (t), the following Total Factor Productivity Growth (TFPG) index is derived:

²² Changes of parameter A over time represent “Hicks-neutral” technical progress. This implies that with better technology, the same amount of inputs can produce a larger amount of output. In the Solow model, technical progress is “exogenous” as it always occurs independently from the use of inputs of production.

$$TFPG = \ln \left[\frac{A(t)}{A(t-1)} \right] \quad (2.3)$$

Based on the Divisia index approach, each term in the right hand-side of (2.2) can be expressed as a deviation from the value of the previous year. Therefore, the final *TFPG* index is given by:

$$TFPG = (\ln Y - \ln Y_{t-1}) - \frac{1}{2} \sum_{r=L,E,M,K} (s_{r,t} + s_{r,t-1})(\ln X_{r,t} - \ln X_{r,t-1}) \quad (2.4)$$

where *Y* and *X* represent the amount of output and input, respectively. The cost share of each input in the total cost of production is denoted by *s*. Labour input is measured by the number of paid employees, energy input includes purchases of fuel and electricity and material input refers to purchases of raw materials. All of the above variables are converted into real values using the corresponding annual deflator indices, which are expressed in 2000 constant prices. More specifically, gross output is deflated by using output price indices at the 2-digit industry level as reported by the NSSG. Real values of material and energy inputs are obtained by using price indices of intermediate and energy goods, respectively.²³ Table (2.2) shows the average values of *TFPG* for all industries in the sample.

2.4.2 Calculation of the Capital Stock Series

The capital input (*K*) used in equation (2.4) is a stock measure computed from the perpetual inventory method (PIM), which accumulates flows of investment over time.²⁴ Investment data are corrected for price changes with a price index of capital goods taken from the NSSG. The formula of capital stock is as follows (industry subscripts are omitted):

$$K_t = (1 - \delta)K_{t-1} + I_{t-1} \quad (2.5)$$

²³ The price deflators reported by NSSG for intermediate, energy and capital goods are in an aggregate form. Therefore, the above price indices are the same for all industries every year.

²⁴ Investment flows include spending on land, buildings, transport and furniture. Note, capital stock does not include investment in machinery to avoid double counting bias as the latter will be used for the construction of machinery stock per output.

Equation (2.5) states that capital input at year t is equal to the depreciated capital stock at $t-1$ plus the value of investments (I) at year $t-1$.

The construction of capital stock in (2.5) is subject to a number of issues that need further clarification. A standard issue is to define a rate of depreciation. Given the relatively short period of study, we consider a straight-line depreciation rate, which assumes that the value of asset declines by the same amount each period (OECD Manual (2001)). This rate is currently assumed to be 5% for all industries. The current values of capital stock remain qualitatively unchanged even if we are experimented with a depreciation rate of 7% or 10%.

The construction of a consistent capital stock series from (2.5) presupposes that one knows the value of capital stock in the first year of the time series. Following Young (1995), Keller (2000) and Liao et al. (2007), we initialise the series of capital stock assuming that the growth rate of investment in the time period under study is representative of the growth rate of investment at years prior to the beginning of the series. Under this consideration, the initial capital stock, K_{1993} , is calculated using the steady-state relation between the capital stock and the level of investment:

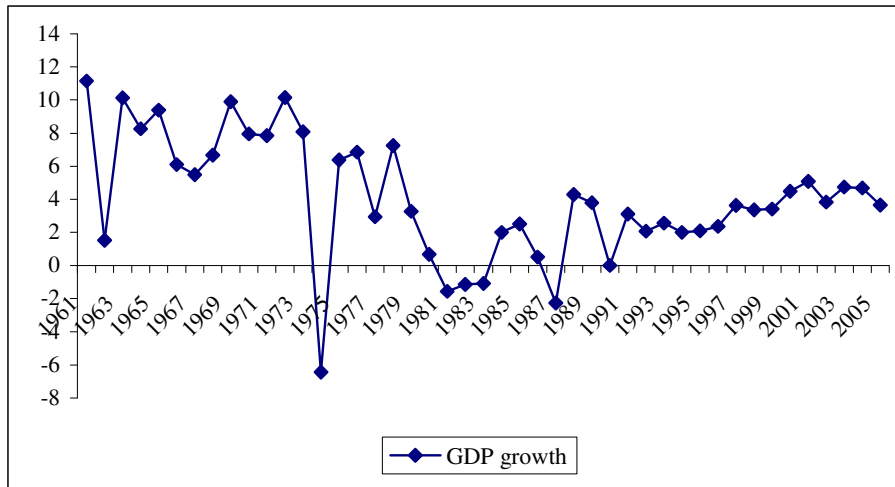
$$K_{1993} = \frac{I_{1993}}{g^E + \delta} \quad (2.6)$$

where I_{1993} is investment in fixed capital assets in 1993, divided by the industry's average annual growth rate of investment in fixed assets over the sample period, g^E , plus the annual depreciation rate δ of fixed assets. Since equation (2.6) is only a steady state approximation, there will be measurement errors that are likely to affect the capital stock estimates.

Investment decisions have a strong cyclical character, for example, during a recession investments decrease below their long-term time trend while the opposite is true during an expansion. Figure (2.4) shows the GDP growth rate of the Greek economy over the period 1960-2005. The average growth rate over the period is 3.9% and the growth rate in 1993 is 2.5%. This

implies that the economy does not deviate substantially from its long term growth path in the year used to initiate the capital stock series.

Figure 2.4 Annual GDP Growth Rate of the Greek Economy



The measurement of capital stock should be adjusted by controlling for the procyclical movements of the investment input, these adjustments of capital stock measure for the degree of capacity utilisation. This adjustment allows us to minimise the influence of cyclical movements on the use of capital input and thereby to *TFPG*. Unfortunately, a capacity utilisation index is only available for manufacturing as a whole but not for individual industries. Based on the above considerations and on lack of data in capacity utilisation, we leave capital stock unadjusted for the degree of capacity utilisation. The reader should be aware of the various limitations encountered in calculating capital stock and their effects on the measurement of TFP when interpreting the results. On the contrary to the present methodology, Chapter 4 of the thesis in which a relative TFP is calculated between Greece and Germany, the series of capital stock is adjusted for capacity utilisation. In such a case, this adjustment is necessary as the degree of utilisation- even if it is in an aggregate form within countries- is different between countries and thus can affect the bilateral TFP comparisons.

2.4.3 Technology Variables

To assess the impact of technological competitiveness on exports, the present study applies three different measures. These are the number of domestic patents, the share of R&D expenditure

to value added and machinery stock per output. The first two variables represent flow measures while the third one is constructing from a perpetual method accumulating investment in machinery equipment over time.

Domestic patents are obtained by the Industrial Property Organisation (IPO) and referring to product and process patents granted to Greek firms and institutions. The product classification of IPO follows the standard European Classification System (ECLA) and the correspondence from ECLA to the 3-digit NACE classification has been done by the author himself.²⁵ Data on R&D are only available at the 2-digit industry level and are taken from OECD-Science and Technology Indicators database. Missing R&D data from the original OECD database are filled by using an interpolation STATA routine.²⁶ As mentioned above, machinery equipment per output is a stock measure and it is computed from NSSG data. The perpetual formula used to calculate stock of machinery equipment is identical to those in (2.5) and (2.6).

2.4.4 Capacity Pressure and Domestic Profitability

The first variable of domestic market forces attempts to capture the effects of internal capacity pressure. This measure is a close approximation of the industry's business cycle. Such a measure is suggested by Sullivan (1985) and is specified as the percentage difference between the deflated annual output and the maximum output over a five-year period including the year of the observation.

$$IBC = Y_{i,t} - Y_{\max} \quad (2.7)$$

where *IBC* abbreviates industry business cycle, $Y_{i,t}$ is industry's output value at year t and Y_{\max} is the maximum output in the five-year period. There are different ways to measure domestic profitability

²⁵ Further information about the ECLA and the Industrial Property Organisation (IPO) can be found at www.obi.gr. The correspondence list from ECLA to 3-digit NACE is available from the author upon request.

²⁶ OECD converts values from national currencies to Euros using the exchange rate of the year that the associated country enters the EMU. To ensure consistency with the original NSSG database, R&D data converted to Greek drachmae using the following exchange rate 1Euro=340.750 DRC. No further conversions are undertaken to correct R&D values for price changes (due to lack of a reliable price index), hence R&D figures throughout the analysis are expressed in current prices.

and each of them shares its own merits and drawbacks (Schmalensee (1989)). This study employs two alternative measures of profitability to represent the different root of the sources that affect it. The first variable is a standard measure of profit margin (PM) on sales defined as:

$$PM_{i,t} = \frac{sales_{i,t} - VC_{i,t}}{sales_{i,t}} \quad (2.8)$$

where VC are industry's variable costs including labour compensation and purchases of intermediate inputs (i.e. both raw materials and energy inputs). The advantage of this measure is that constitutes a close approximation of Lerner's index for the degree of monopoly in the industry, which is defined as: $(price - MC)/MC$. The second profitability measure refers to the rate of profitability (PR) and it is defined as:

$$PR_{i,t} = \frac{PM_{i,t}}{(I/Y)_{i,t}} \quad (2.9)$$

where PM is the variable defined in (2.8) and (I/Y) is the ratio of investment in tangible goods over output. This measure is based on the notion that profit rate depends on the industry's capital-output ratio. Considering that profit rates are influenced by demand fluctuations, industries with high capital-output ratios correspond to these fluctuations through capacity utilisation adjustments and less through price changes (Tsaliki and Tsoulfidis (2005)). Therefore, the rate of profitability is expected to be smaller in industries with relatively high capital-output ratios.

2.4.5 Demand Side Variable

The demand side variable used in the present empirical function is a measure of income of the foreign country (importing country). Two potential problems are encountered in attempting to measure the impact of the demand side drivers of exports. First, any measure of foreign income is industry invariant. Second, Greek exports to a particular destination are likely to constitute a very

small share of this country's total imports, and thus a change in foreign country's income might not influence substantially the demand for Greek exports. The empirical analysis of the following section will reveal whether this pattern exists in the present study. As far the first problem is concerned, we follow Bernard and Jensen (2004a) that construct an industry-specific measure of foreign demand as follows:

$$D_{i,t} = \sum_{j=1}^6 z_{i,j,t} GDP_{j,t} \quad (2.10)$$

where j indicates the six main destinations of Greek exports. These are Cyprus, France, Germany, Italy, Spain and UK.²⁷ The value of GDP of each major trading partner at time t is adjusted by the share of exports, $z_{i,j,t}$, of industry i to country j at year t . In words, equation (2.10) is a weighted foreign income measure representing the share of exports from the industry to the country.

²⁷ Greek manufacturing industries ship to these countries more than the 60 percent of their total exports.

Table2.2 Total Factor Productivity Growth (TFPG) of Greek Manufacturing Industries

NACE Code	Industry Description	TFPG
151	Production, Processing and Preserving of Meat	-0.130
152	Processing and Preserving of Fish and Fish Products	-0.062
153	Processing and Preserving of Fruit and Vegetables	-0.095
154	Vegetable and Animal Oils and Fats	-0.055
155	Dairy Products	0.020
156	Grain Mill Products, Starches and Starch Products	-0.041
157	Prepared Animal Feeds	-0.022
158	Other Food Products	N/D
159	Beverages	0.018
160	Tobacco Products	0.011
171	Preparation and Spinning of Textile Fibres	-0.002
172	Textile Weaving	-0.013
173	Finishing of Textiles	0.001
174	Made-Up Textile Articles, Except Apparel	-0.009
175	Other Textiles	0.041
176	Knitted and Crocheted Fabrics	0.056
177	Knitted and Crocheted Pullovers	0.078
182	Other Wearing Apparel and Accessories	0.114
183	Dressing and Dyeing of Fur	0.137
191	Tanning and Dressing of Leather	0.017
192	Luggage, Handbags and the Like, Saddlery and Harness	0.020
193	Footwear	-0.001
201	Sawmilling and Planing of Wood	0.012
202	Veneer sheets Plywood, laminboard, particle board	0.001
203	Builders' Carpentry and Joinery	-0.011
204	Wooden Containers	-0.081
205	Other Products of Wood; Articles of Cork	-0.036
211	Pulp, Paper and Paperboard	-0.038
212	Articles of Paper and Paperboard	-0.084
222	Printing And Service Activities Related To Printing	-0.111
223	Reproduction of Recorded Media	-0.108
232	Refined Petroleum Products	-0.125
241	Rubber Products	-0.121
242	Plastic Products	-0.131
243	Glass and Glass Products	-0.267
246	Ceramic Tiles and Flags	-0.041
247	Bricks, Tiles and Construction Products	-0.109
251	Cement, Lime and Plaster	-0.046
252	Articles of Concrete, Plaster and Cement	-0.022
261	Cutting, shaping and finishing of ornamental	N/D
262	Other Non-Metallic Mineral Products	-0.090
263	Basic Iron and Steel and of Ferro-Alloys	-0.058
264	Other first processing of iron and steel	-0.076
265	Basic Precious and Non-Ferrous Metals	-0.164
267	Structural Metal Products	-0.088
268	Other Non-Metallic Mineral Products	-0.092
271	Casting of Metals	-0.142
272	Manufacture of Tubes	-0.083
273	Other first processing of Iron and Steel	-0.082
274	Basic Precious and Non-Ferrous Metals	-0.136
275	Casting of Metals	-0.091
281	Machinery for the Production	-0.091
282	Other General Purpose Machinery	-0.008
285	Weapons and Ammunition	-0.013
286	Domestic Appliances	-0.041
287	Electric Motors, Generators and Transformers	-0.033

291	Electric Motors, Generators and Transformers	-0.045
292	Electricity Distribution and Control Apparatus	0.039
293	Insulated Wire and Cable	-0.047
294	Machine Tools	-0.223
295	Other Special Purpose Machinery	-0.068
296	Manufacture of weapons and ammunition	-0.118
297	Electric Domestic Appliances	-0.062
300	Office Machinery and Computers	-0.397
311	Electric Motors, Generators and Transformers	-0.033
312	Television and Radio Transmitters	-0.098
313	Insulated wire and cable	-0.209
314	Medical and Surgical Equipment	N/D
315	Instruments and Appliances for Measuring	-0.233
316	Industrial Process Control Equipment	-0.073
321	Optical Instruments and Photographic Equipment	-0.019
322	Motor Vehicles	N/D
323	Bodies (Coachwork) for Motor Vehicles; Trailers and Semi-Trailers	-0.177
331	Parts and Accessories for Motor Vehicles and Their Engines	-0.133
332	instruments and appliances for measuring	-0.146
334	optical instruments and photographic equipment	0.220
341	Motorcycles and Bicycles	-0.117
342	Other transport equipment	0.282
343	Accessories for Motor Vehicles and Their Engines	-0.146
351	Jewellery and Related Articles	-0.037
352	Railway and Tramway Locomotives and Rolling Stock	-0.098
353	Aircraft and Spacecraft	-0.121
354	Motorcycles and Bicycles	-0.088
362	Jewellery and Related Articles	0.049
364	Sports Goods	-0.130
365	Miscellaneous Manufacturing	-0.062
366	Games and Toys	-0.095
371	Recycling of Metal Waste and Scrap	-0.055

Note:

TFPG is a sample average of Total Factor Productivity index as calculated in equation (2.4)

2.5 Econometric Model- Estimation and Results

2.5.1 Benchmark Specifications-The Pooled Model

The export determination function includes the logarithmic values of the variables discussed in section (2.4):

$$Z = f(TFPG, MACH_OUT, RD_SHARE, PAT, IBC, PM, PR, D) \quad (2.11)$$

where Z is a measure of export performance, $TFPG$ is the index of Total Factor Productivity Growth, $MACH_OUT$ is the machinery stock per output, RD_SHARE is the ratio of R&D to value added, PAT is the number of domestic patents used in each industry, IBC is industry's business cycle, PM and PR measure profit margin and profit rate, respectively and D is the sum of adjusted income indices in a group of export destination countries.

The general formulation of the econometric model is $y_{i,t} = \beta_{i,t} X_{i,t} + u_{i,t}$, where i and t are indices of industry and time and vector \mathbf{X} includes the export determinants mentioned above. The fact that the analysis is based on time-series-cross-section (TSCS) data permits us to control for unobserved heterogeneity. Therefore, the initial model takes the form:

$$y_{i,t} = \beta X_{i,t} + v_i + e_{i,t} \quad (2.12)$$

where v is a fixed industry intercept and e is a well-behaved error term with conditional zero mean (i.e. $E(e_{i,t} / X_{i,t}) = 0$) and constant variance. The variables included in the vector \mathbf{X} are introduced in the estimatable equation one year lagged to control for simultaneity and endogeneity bias that might exist between the contemporaneous export variables and the determinants of export performance. In a trade context, the lagged dependent variables also represent the time needed in order for industries to expand commercial activities in foreign markets. Nonetheless, the unobserved effects v_i in (2.12) are likely to

be correlated with the other right-hand side variables leading to biased estimates if a standard OLS technique is applied. The within groups-fixed effects (FE) estimator transforms variables in (2.12) such as the original observations are expressed as deviations from industry means. Therefore, the use of this estimator removes any potential correlation between dummies and the other right-hand side variables.

Results from benchmark specifications are reported in Table (2.3). The measures of export performance are the growth rate of real exports and the ratio of exports to output. The set of the right hand side variables initially includes *TFPG*, *IBC*, *MACH_OUT* and *PM*. A number of issues need special attention regarding the behaviour of the error term in a panel data model. The modified Wald statistic based on Greene's (2003) rejects the null hypothesis of a homoscedastic error term (i.e. $\text{var}(e_{i,t}^2) = \sigma_i^2$). Similarly, the Pesaran test specifies whether the assumption of an independent error term across-sections is violated (i.e. $E(e_{i,t}e_{j,t}) = \sigma_{i,j}$, for any industry $i \neq j$). Empirical export models are regularly characterised by high degree of persistence. This hypothesis is tested using a test of first order serial correlation (i.e. $\text{cov}(e_{i,t}e_{i,t-1}) \neq 0$) proposed by Wooldridge (2002). There is a considerable autocorrelation problem when the export ratio is used as a measure of export performance. As expected, the measure of export growth is already dynamic itself and thus any past effect is already taken into account.

The first three columns in Table (2.3) show results from a FE estimator. The F-statistic reported in the lower part of the table indicates that the inclusion of fixed industry effects is significant. The first two columns display default FE estimations without correcting for the structure of the error term, while the third column presents results from a FE specification in which the error term is first order autoregressive - AR(1).

To correct for heteroscedasticity as well as for cross-industry correlation in the disturbance term, we use the panel corrected standard error estimator (PCSE) following the strategy developed by Beck and Katz (1995). This procedure applies "panel corrected standard errors" to correct for group-wise

heteroscedasticity and contemporaneous correlation of the errors. This procedure keeps the OLS estimates of the parameters and replaces standard errors with “panel corrected standard errors”. As far as the correction of autocorrelation is concerned, the appropriate way is to consider a dynamic specification that treats more systematically the existence of the lagged feedback effects. A benchmark dynamic specification is the autoregressive distributed lag (ADL) model, which includes a lagged dependent variable in the right –hand side of (2.12). Alternatively, one can control for persistence by considering that the disturbance term follows an AR(1) process as $e_{i,t} = \rho e_{i,t-1} + \eta_{i,t}$. This is the procedure performed in the FE-AR(1) specification and it is also available in the PCSE. As Katz and Beck (2004) argue when ρ is relatively small²⁸ then shocks rapidly die out returning to equilibrium quickly. In such a case, modelling feedback effects either by considering a lagged dependent variable (LDV) or by specifying an AR(1) error term makes little difference. As reported in Table (2.3), the estimated parameter of ρ is never above 0.25, so according to Beck and Katz (2004) implying that LDV and AR(1) produce similar results.

Turning to the estimated coefficients, Table (2.3) reveals a clear pattern regarding the impact of productivity on export performance. The estimated coefficient of TFPG is positive and statistically significant in every specification. The second robust finding from Table (2.3) is that industry’s business cycle has a reverse effect on export activity. The results about the relationship between profitability and exports vary between the two measures of export performance. Firstly, there is a clear positive effect of profitability on the growth rate of exports. This pattern suggests that profitability boosts the volume of exports but it does not necessarily increase exports as a share of total output. The latter finding provides support for the hypothesis that increased profitability reflects the industry’s monopolistic position in the domestic market, which usually serves as a disincentive for export expansion. The impact of

²⁸ A relatively small value of ρ is around 0.20. In this case, there is rapid speed of adjustment implying that the dependent variable follows a very short memory process. As the estimated value of ρ becomes larger and very close to unity then the dependent variable follows a non-stationary process. In this case, the standard ADL model or the PCSE estimator with AR(1) process of the residual are not the appropriate estimation techniques.

embodied technological change through investment in machinery is of minor statistical significance in most of the specifications.

Table 2.3 Export Determinants at the 3-Digit Industry Level, FE and PCSE Specifications

COEFFICIENT	Exports Growth FE (1)	Export Ratio FE (2)	Exports Ratio FE- AR(1) (3)	Exports Growth OLS- PCSE (4)	Export Ratio OLS- PCSE (5)	Exports Growth OLS- PCSE (6)	Export Ratio OLS- PCSE (7)
<i>TFPG</i>	0.015* (1.77)	0.404*** (3.10)	0.24*** (2.57)	0.007 (0.56)	0.296*** (3.98)	0.022** (2.49)	0.292*** (3.99)
<i>MAC_OUT</i>	0.003 (1.05)	0.027 (0.65)	-0.27*** (4.06)	0.002 (1.60)	-0.006 (0.092)		
<i>IBC</i>	-0.03*** (4.75)	-0.089 (0.76)	-0.62*** (6.77)	-0.03*** (3.15)	-0.30*** (2.96)	-0.03*** (3.17)	-0.30*** (3.34)
<i>P M</i>	0.01*** (3.64)	-0.12*** (2.74)	0.18 (0.58)	0.003* (1.75)	-0.052 (0.86)	0.0102** (2.37)	-0.066 (1.05)
<i>PAT</i>						0.000 (0.074)	-0.023** (2.35)
<i>P R</i>							
Observations	533	533	533	628	628	636	636
Number of Industries	67	67	67	85	85	86	86
Industry Fixed Effects				No	Yes	No	Yes
R-squared	0.07	0.05	0.10	0.15	0.91	0.15	0.91
Diagnostics							
F-test	0.79 (0.882)	47.95 (0.00)	10.75 (0.00)				
Wald test	31301.53 (0.00)	132.47 (0.00)					
Pesaran-Cross Sectional Dependence	3.002 (0.002)	22.45 (0.00)					
Wooldridge Test for autocorrelation, F(1,66)	0.005 (0.94)	22.035 (0.00)					
rho					0.243		0.233

Notes:

All variables are lagged by one year. Absolute t-statistics are shown in parentheses and the asterisks correspondence is *significance at 10%; ** significance at 5%; ***significance at 1%. Each observation is weighted by the inverse of the number of firms in the industry to control for differences in the size of industries. Figures in parentheses below the diagnostic test refer to p-values. F-test refers to the hypothesis whether the inclusion of industry dummies is jointly significant. Wald statistic is reported after testing for heteroscedasticity in panels; the null hypothesis is that the residual term in all industries has the same variance. Pesaran statistic refers to cross-sectional correlation of the error terms, the null hypothesis is that error terms are independent across industries. All estimations are performed in STATA 9 with the command *xtreg* for equations in columns (1)-(2); *xtregar* for equation in column (3); and *xtpcse* for equations (4)-(7).

The impact of foreign income and R&D share on exports is estimated in Table (2.4). The sample in Table (2.4) has been reduced because there are not available data of R&D and exports to specific destinations at the 3-digit level thus; the results reported refer to the 2-digit industry level. Table (2.4) shows that estimates are less robust compared to those in Table (2.3) which implies that when we estimate an aggregate sample is less informative about the determinants of exports, possibly due to serious aggregation bias. We speculate that as we aggregate data over the 2-digit level of industrial classification many heterogeneous industries are lumped together generating various offsetting effects regarding the determinants of exports.²⁹

The coefficients of TFPG and the industry's business cycle in Table (2.4) maintain the expected sign but they are of minor statistical significance. The same pattern applies for the measures of technological competitiveness. The estimated coefficient of the R&D share has the sign predicted by the theory but it is statistically significant at the 10 percent level and only when export activity is measured by the growth rate of exports. The last two columns in Table (2.4) display results after considering as a measure of industry's technological capability the ratio of R&D personnel to total employment. The effect is positive but it cannot be regarded as statistically significant at any conventional level. In the exports growth specifications, the estimate of profit margin is positive and statistically significant confirming the finding reported in Table (2.3). It is worth emphasising that the present study is unable to provide robust evidence as to whether changes in foreign income can affect the demand for Greek exports. The adjusted GDP index of the six major export partners of Greece is marginally negative and insignificant. Given that this variable is a proxy for income, a negatively signed coefficient suggests that Greek exports represent inferior goods for the residents in the destination countries. Therefore, an increase in consumer's income implies a decrease in the demand for these goods. Certainly, this interpretation should have gained more credibility if the estimated

²⁹ This problem is mitigated to some degree when we estimate the export determination model for different groups of economic activity, see section 2.5.2.

coefficients were statistically significant at conventional levels. The most likely explanation of the insignificant effect of foreign income on exports lies in the fact that Greek exports to these countries are only a very small fraction of the total imports of these countries.

The export ratio specifications of the PCSE estimator in Table (2.4) have very high R-squared values despite the fact that most of the estimates are statistically insignificant. This effect possibly reflects the fact that this model is estimated specifying an AR(1) process of the error term. This transformation of the residual is necessary since the Wooldridge test reported in the FE specification clearly indicates the existence of autocorrelation. As commented earlier, this feature suggests that movements in the export ratio can be effectively described by its lagged values. Indeed, running a dynamic specification of the export ratio equation reveals that the lagged dependent variable (LDV) in the right-hand side has a positive and statistically significant coefficient. Nonetheless, controlling for persistence via an AR(1) process or via an LDV specification have no impact on the fundamental specification of the model. The fact that the export ratio equations produce many insignificant estimates highlights the issue of the aggregation bias yielded in the 2-digit industry level data.

Table 2.4 Export Determinants at the 2-Digit Industry Level, FE and PCSE Specifications

COEFFICIENT	Exports Growth FE (1)	Export Ratio FE (2)	Exports Growth OLS- PCSE (3)	Export ratio OLS- PCSE (4)	Exports Growth OLS- PCSE (5)	Export ratio OLS- PCSE (6)
<i>TFPG</i>	0.001 (0.089)	0.255 (1.34)	0.02 (0.98)	0.23 (0.97)	0.02 (1.25)	0.21 (0.82)
<i>R&D_ SHARE</i>	0.001 (0.28)	0.039 (1.00)	0.00 (0.85)	0.132* (1.95)		
<i>IBC</i>	-0.023*** (2.68)	-0.179 (1.10)	-0.022* (1.83)	-0.09 (0.43)	-0.0249* (1.95)	-0.18 (0.91)
<i>PM</i>	0.0126*** (4.65)	0.027 (0.54)	0.011*** (3.25)	0.04 (0.62)	0.014*** (3.13)	0.05 (0.74)
<i>Foreign Income(I)</i>	-0.00652* (1.73)	-0.025 (0.37)	0.00 (0.25)	0.01 (0.078)	0.00 (0.035)	-0.04 (0.36)
<i>R&D personnel</i>					-0.01 (0.93)	0.24 (1.15)
Observations	112	112	112	112	112	112
Number of Industries	14	14	14	14	14	14
Industry Fixed Effects			No	Yes	No	Yes
R-squared	0.33	0.06	0.37	0.91	0.42	0.91
Diagnostics						
	1.45	32.62				
F-test	(0.15)	(0.00)				
	731.50	31.33				
Wald Test, Chi2(14)	(0.00)	(0.00)				
Pesaran-Cross	2.804	8.48				
Sectional Dependence	(0.00)	(0.00)				
Wooldridge test						
for autocorrelation,	0.367	11.899				
F(1,13)	(0.555)	(0.004)				
rho				0.201		0.265

Notes:

All variables are lagged by one year. Absolute t-statistics are shown in parentheses and the asterisks correspondence is *significance at 10%; ** significance at 5%; ***significance at 1%. Each observation is weighted by the inverse of the number of firms in the industry to control for differences in the size of industries. Figures in parentheses below the diagnostic test refer to p-values. F-test refers to the hypothesis whether the inclusion of industry dummies is jointly significant. Wald statistic is reported after testing for heteroscedasticity in panels; the null hypothesis is that all industries have the same variance. Pesaran statistic refers to cross-sectional correlation of the error terms, the null hypothesis is that error terms are independent across industries.

Summarising the main results of Tables (2.3) and (2.4), it could be argued that estimations from a disaggregate sample of industries produce more robust results. The analysis at the 3-digit industry level indicates that *TFPG* has a positive impact on exports throughout the whole set of specifications. The productivity index used accounts for *x*-efficiency improvements, thus an increase in this index indicates

that industries achieve a more optimal allocation of the resources. From an industry's point of view, productivity gains are directly related to cost reductions, which enable industries to use a part of this surplus in order to foster export activity. The general formulation of the productivity measure allows us to give many different interpretations of the real sources of productivity improvements. One of them is that productivity improvements are derived from successful restructuring efforts undertaken by Greek manufacturers such as better organisational schemes. This does not exclude the possibility that technological change and various institutional reforms can also serve as conduits of productivity growth. To some degree, the measure of TFPG can be considered as an indicator of price competitiveness since cost reductions are likely to pass-through in product prices. To adopt this interpretation as it stands is hazardous, since the current productivity measure is in absolute terms³⁰ without comparing productivity of Greek manufacturers relative to their international counterparts.

The current finding regarding TFP is consistent with other studies that estimate an export determination model, such as Goldar (1989) and Anderton (1992). In these studies, authors apply similar measures of cost competitiveness verifying their positive relationship with export activity. The present finding is also consistent with another section of the exports literature, which analyses the effects of productivity on export share dynamics (Wolff (1995), Van Reenen et al. (2001) and Montobbio (2003)). The main differences of the present work with the above studies are that the latter refer to a group of countries using a partial equilibrium framework to investigate whether improvements in relative productivity increase export share in international markets. The underlying spirit of the results of both the present and the above studies tends to verify that an increase in productivity (either in a relative or in an absolute sense) is a path of better export performance.

The results shown in Table (2.3) convincingly support the argument that domestic demand has reverse effects on export performance. The variable utilised to approximate the domestic demand

³⁰ The term "absolute" means that base of comparison here is industry productivity in the previous year and not productivity of any other reference industry.

forces–industry's business cycle (*IBC*) - proved negative and statistically significant at the 1% level. This finding supports the scenario that exporting becomes a residual activity when industries enjoy a relatively large domestic market. The same negative relationship, though much less significant, seems to hold between domestic profitability and exports. Both variables used to measure domestic profitability are negative determinants of export ratio. Apart from industry's specific characteristics, the domestic demand forces are also subject to changes in the macroeconomic policy. Therefore, policy makers should be aware of the fact that an expansionary fiscal policy might cause a negative influence on the export activity.

Table (2.3) reveals an interesting pattern concerning the effect of technological indicators on export performance. The first remark is that the impact of the industry's technological capability differs according to the measure of export activity used. The results indicate that machinery-equipment per output and domestic patents have a negative effect on export ratio, while their impact on the growth rate of exports is positive. The negative effect clearly contradicts theoretical predictions while it provides more insightful evidence about the specialisation areas of the Greek exports. Greece has a comparative advantage in textiles and similar unskilled labour oriented industries (Arghyrou and Bazina (2003)), implying that Greek manufacturers have substantial export involvement in these industries. Specialised machinery equipment that embodies new technological capabilities can effectively improve export opportunities in industries that use intensively this type of inputs and certainly this is not the case for the industries in which Greece has a comparative advantage.

On the contrary, the analysis based on the 2-digit industry level proves a positive influence of R&D intensity on export activity. However, this finding does not contradict the arguments discussed above about the main areas of export specialisation of the Greek manufacturers. The importance of R&D lies far beyond being a simple technological indicator. In fact, R&D activity is divided into product and process innovation. The former role of R&D can be regarded as a proxy of technological indicator since the principal outcome of product R&D effort is to generate technologically

sophisticated products. However, R&D process facilitates benefits that improve the techniques of production, and thus reducing costs. The present data refer to aggregate R&D expenditure without allowing us to explore further the aforementioned features. With these considerations in mind, one can argue that the positive estimated coefficient of R&D in Table (2.4) is likely to contribute to productivity improvements leading implicitly to better export performance. A similar argument is found in Sveikauskas (1983), who considers that R&D and not investment in specific capital assets is the key technological advantage of industrialised countries.

2.5.2 Estimations per Group of Economic Activity

The econometric specifications presented in the previous sub-section pool observations across industries and years without allowing coefficients to vary across industries or sub-groups of industries. This estimation strategy assumes that the effect of the potential export determinants is homogenous across all industries in the sample. However, this consideration is likely to be misleading if heterogeneous production patterns across industries create different underlying motives for a successful export performance. For example, in technology intensive industries, the sensitivity of exports to cost changes might be of less importance as relative to unskilled labour intensive industries. This issue can be addressed more systematically by allowing coefficients to differ across industry groups. Pavitt (1984) provides a taxonomy of industries with special reference to trade and competitiveness. This taxonomy classifies industries according to the nature of their economic activity. The four groups of industries of Pavitt's taxonomy³¹ are Supplier Dominated (**SDOM**), Science Based (**SCIB**), Scale Intensive (**SCAI**), Specialised Suppliers (**SPEC**). Specification (2.12) is re-estimated for each Pavitt group separately. The results are shown in Table (2.5).

³¹ A more detailed discussion of Pavitt taxonomy is shown in Appendix A2.6.

Table 2.5 Export Determinants per Group of Economic Activity

FE AR(1)				
COEFFICIENT	SDOM	SCIB	SCAI	SPEC
<i>TFPG</i>	0.604*** (2.62)	0.108 (0.57)	0.356* (1.97)	0.552** (2.05)
<i>MAC_OUT</i>	-0.164 (1.08)	-0.122 (0.60)	-0.286*** (3.00)	0.152** (2.11)
<i>IBC</i>	-0.581*** (3.17)	-0.451* (1.96)	-0.841*** (5.34)	-0.271 (1.02)
<i>PM</i>	-0.176*** (3.06)	0.0185 (0.27)	-0.124 (1.05)	-0.0951 (1.52)
	161	73	200	121
Number of Industries	24	12	32	16
Observations	185	85	232	121
R-squared	0.14	0.10	0.16	0.11
Diagnostics				
F-test	92.35 (0.00)	19.57 (0.00)	36.27 (0.00)	53.55 (0.00)
Wald Test	31.56 (0.13)	14.75 (0.25)	183.04 (0.00)	41.64 (0.00)
Wooldridge Test	3.627 (0.00)	4.201 (0.06)	25.821 (0.00)	1.946 (0.18)
OLS-PCSE				
<i>TFPG</i>	0.339 (1.28)	0.286*** (3.41)	0.322 (0.84)	0.730* (1.76)
<i>MAC_OUT</i>	0.116 (0.89)	-0.157 (1.41)	0.15 (1.30)	0.0911* (1.87)
<i>IBC</i>	-0.0926 (0.40)	-0.464** (2.23)	-0.205 (0.86)	-0.346 (1.22)
<i>PM</i>	-0.197*** (3.12)	0.00758 (0.12)	-0.0381 (0.19)	-0.0937 (1.23)
	185	85	232	121
Number of Industries	24	12	32	16
Sector Dummies	Yes	Yes	Yes	Yes
Observations	185	85	232	121
R-squared	0.96	0.84	0.85	0.06

Notes:

All variables are lagged by one year. The dependent variable in the specifications of the table is export ratio. Absolute t-statistics in parentheses and the asterisk correspondence is * significance at the 10%; **significance at the 5%; ***significance at 1%. Each observation is weighted by the inverse of the number of firms in the industry at the first year of the sample to control for differences in the size of industries. For the interpretation of the diagnostic tests, see notes in tables (2.3) and (2.4) and the main text.

Specifications in Table (2.5) are focused only on the export ratio as an indicator of export performance and apply two estimation methods; FE with an autoregressive error term and PCSE. The signs of the estimated coefficients of *TFPG* and *IBC* are consistent with the theoretical priors (i.e.

positive and negative respectively) and remain as such regardless the estimation method. This pattern suggests that all groups have the same responsiveness to cost and domestic demand changes. The technological indicator used is machinery per output since the use of this measure allows us to estimate the model at the 3-digit industry level. The impact of machinery per output on exports is negative in three out of the four groups. Investment in advanced machinery equipment has a positive impact only on the specialised suppliers group. The same pattern holds even if the number of patents is used as an indicator of the industry's technological activity. This finding confirms the argument mentioned before that increasing an input of production brings beneficial results only if the industry uses intensively this input. Additionally, the positive sign of machinery per output in the specialised suppliers (SPEC) group indicates to some degree that the taxonomy proposed by Pavitt distinguishes accurately the different production patterns across industries. It is worth noting that the upper part of Table (2.5), where the FE estimates are presented, the R-squared values are quite low while in the lower part when industry fixed effects are included, the goodness of fit is improved massively. The low value of the R-squared coefficient indicates that there are many factors to be included in the export determination model in order to improve our understating about the variation in export performance.

2.5.3 Further Econometric Specifications of the Export Determination Model

In this section, some additional specifications are tested aiming to provide a sense of robustness in the econometric results shown in the previous sub-sections. The first test seeks to consider the complementarity effect between the disembodied and the embodied technological change as these reflected by the variables of TFPG and machinery per output, respectively. The complementarity effect signifies the importance of technologically advanced equipment on the estimated relationship between TFPG and export performance. In practise, this effect is tested by using the interacted term of TFPG with machinery per output ($MAC_OUT \times TFPG$). A positive estimate of the interacted variable points

out that the higher the stock of machinery per output; the higher is the marginal effect of productivity growth.

A similar effect might exist between embodied technological change and the quality of human capital. Investment in advanced machinery equipment becomes more effective and successful as long as there are skillful workers able to operate this sophisticated equipment. Consequently, the potential effect of embodied technological change on export performance should be combined with the skills of the labour force. As a proxy of human capital we use the ratio of labour compensation per worker. The use of this proxy ($MAC_OUT \times Skill$) underpins that the skills and the qualifications of workers are represented mainly by higher earnings.

To estimate the above specifications, the strategy followed is the same to the one applied in Tables (2.3)-(2.5). In all models, the error term follows an AR(1) process and it is corrected for panel heteroscedasticity and cross-sectional correlation. These specifications use only the export ratio as the dependent variable³² and the estimates are shown in Table (2.6). The results do not support the complementarity hypothesis discussed above. The interacted term of machinery per output with *TFPG* is negative and statistically significant in both the FE and the PCSE estimations. Taking into account the positive and statistically significant estimate of the linear *TFPG* term documented in Table (2.3), the negative pattern of the interacted term suggests that the positive relation between the disembodied technical change as reflected by *TFPG* and exports turns out to be weaker in the presence of higher machinery per output. Such a result highlights clearly the negative influence of investment in machinery on the Greek export performance.

Columns (2) and (4) in Table (2.6) report results from specifications that test the complementarity effect between human capital and machinery per output. In column (2), the estimate of the interacted term is negative and statistically significant column suggesting that the combination of human capital

³² This is because the estimate of *MACH_OUT* variable in Table (2.3) is statistically significant only when the export ratio is considered as the dependent variable.

with investment in machinery equipment does not generate the expected positive impact on export performance. This evidence confirms the results displayed in columns (1) and (3) indicating once more that investment in advanced technologically equipment is not beneficial for Greek manufacturers even though this equipment is operated by human capital of high quality. The latter pattern contradicts the findings of Montobbio (2003) regarding the effect of the embodied technological change with skill intensity on export share dynamics. Nonetheless, a convincing explanation can be found for this contradiction if one takes into account the propositions of the comparative advantage theory. The negative interacted term found above is likely to indicate that Greece maintains substantial export performance and possibly a revealed comparative advantage in industries that they do not use intensively the advanced machinery equipment. Consequently, investing in this input increases the costs of production without fostering an industry's trade performance.

Table 2.6 Further Specifications of the Export Determination Model

COEFFICIENT	FE AR(1) (1)	FE AR(1) (2)	OLS-PCSE (3)	OLS-PCSE (4)
<i>MAC_OUT</i> × <i>TFPG</i>	-0.078** (2.37)		-0.094*** (3.64)	
<i>MAC_OUT</i> × <i>Skill</i>		-0.261*** (4.79)		0.0146 (0.28)
<i>TFPG</i>		0.203** (2.18)		0.289*** (3.87)
<i>PAT</i>	-0.014* (1.91)	-0.009 (1.31)	-0.022** (2.29)	-0.022** (2.31)
<i>IBC</i>	-0.38*** (5.09)	-0.517*** (6.45)	-0.274*** (3.07)	-0.298*** (3.15)
<i>PM</i>	-0.009 (0.30)	0.0263 (0.82)	-0.085 (1.49)	-0.063 (1.02)
Observations	539	539	628	628
Number of Industries	84	84	85	85
Industry Fixed Effects	No	No	Yes	Yes
R-squared	0.07	0.11	0.91	0.91
Diagnostics				
F-test	50.56 (0.00)	49.29 (0.00)		
Wald Test	275.80 (0.00)	292.65 (0.00)		
Wooldridge Test	24.289 (0.00)	26.868 (0.00)		

All variables are lagged by one year. Export ratio is the dependent variable in all specifications of the table. Absolute t-statistics in parentheses and the asterisk correspondence is * significance at the 10%; **significance at the 5%; ***significance at 1%. Each observation is weighted by the inverse of the number of firms in the industry at the first year of the sample to control for differences in the size of industries. For the interpretation of the diagnostic tests, see notes in Tables (2.3) and (2.4) and the main text.

2.6 Conclusions

Export performance of nations is of particular interest for both policy makers and trade economists. This can be attributed to the fact that export performance can substantially affect economic growth. Trade economists consider that an improvement in export performance constitutes one of the most crucial engines of growth via mainly the spillovers of knowledge and ideas. Apart from the dynamic character of the export activity, one should not ignore the standard static effects derived from exports such as the exploitation of scale economies. The principal goal of the present chapter was to reveal the driving forces of export intensity, which is the prior stage before one starts investigating the existence and the importance of the gains derived from exports. The investigation of the determinants of exports is implemented in the literature from many different conceptual standpoints. The current study chooses to contribute to this long-term research agenda by employing an export determination model. The advantage of this model is that it explores export behaviour from both a supply and a demand side point of view.

A quite innovative element of the present study is the level of disaggregation of the available data set. The current analysis uses Greece as a case study over the period 1993-2003 using a sample of more than 80 manufacturing industries. Working with such a detailed list of manufacturing industries has two clear advantages. The first represents a standard econometric effect, as the number of annual cross-sections is larger and more observations are available, thus, there are more degrees of freedom to support inference. The second advantage is that a disaggregate data set tackles effectively the problem of aggregation bias. This problem is regularly faced by standard industrial classifications since they lump many heterogeneous industrial activities together. The present study confirms the aforementioned problem since the estimation of the same econometric model at the 2-digit industry level produces less robust results than those obtained from the estimations at the 3-digit industry level.

A central focus of the export determination model is to answer whether competitiveness play a particular role on export performance. Two main aspects of competitiveness are analysed, namely cost and technological competitiveness. The main issue about cost competitiveness is whether exports are sensitive to changes in an industry's productivity. The measure of TFP used relies on the non-parametric Divisia index approach, which under certain assumptions can be derived from any underlying production function. Apart from the standard inputs, the present TFP measure includes information for expenditure in energy and material inputs. This allows us to better assess the influence of variable costs in productivity changes and thus in export activity. Throughout various econometric specifications, a strong positive pattern is drawn between export activity and productivity. This finding highlights mainly the impact of *x*-inefficiency on export performance and partially accounts for the impact of price competitiveness. The former effect suggests that reducing *x*-inefficiency losses enables industries to devote resources to expanding activities in foreign markets. The effect of price competitiveness is less direct and based on the assumption that cost reductions are partially passed-through into prices fostering the competitiveness of Greek products in international markets.

A successful export performance is not sensitive only to cost competitiveness. The theory suggests that a set of other technological factors also play an important role on export activity. To quantify the impact of these factors on export performance, the present study employs three different measures, the stock of machinery equipment per unit of output, the number of domestic patents and the R&D expenditure share. The first two measures show that technological indicators are of minor importance in the Greek manufacturing sector. Estimates from the 2-digit level reveal a positive response of exports to R&D confirming the positive association of exports with R&D activity already documented in many studies (see among others, Bhaduri and Ray (2004), Van Reenen et al. (2001)). Nonetheless, the positive effect of R&D can hardly be viewed as robust, which indicates a more general pattern concerning the structure of the Greek manufacturing sector. Greek manufacturing industries are not technology intensive, therefore investing in this type of inputs increases production

costs without necessarily promoting export performance. The above interpretation is not applied to the group of specialised industries, which relies essentially on the use of advanced technological inputs. In this group, investment in embodied technological change brings the desirable results with respect to exports.

Lastly, the findings suggest that the impact of domestic market pressure on export performance is negative. Along with productivity, domestic demand pressure is the second most important determinant of exports. The results also support the view that Greek manufacturers consider exporting as a residual activity. This pattern is also confirmed by the second measure of domestic demand conditions, domestic profitability, but at lower levels of statistical significance.

In a small European country like Greece, export activity offers the opportunity to exploit a larger market. The removal of trade impediments and various structural changes realised in the European economic environment in the last fifteen years open new export horizons for peripheral EU members. A sustainable and successful export policy should be a top priority for a Greek economic policy maker. Following the present analysis, the natural question emerged is which are the ingredients of a successful export policy?

In the present context, any answer to the above question should have necessarily an indirect character. This is due to the fact that the empirical analysis does not use measures such as the exchange rate regime or export subsidies that they serve as automatic promoters of exports. As far as the exchange rate is concerned it is not used as an export determinant since it does not vary in an interesting way at an industry level analysis. Therefore, one cannot state clearly whether the deterioration of drachma in 1998 managed to boost Greek exports. Instead, the lesson that can be drawn from the present analysis is that productivity and domestic market conditions can play an important role on sustainable export performance.

The former variable represents in fact, changes in disembodied technological change that effectively improve the industry's cost performance. Disembodied technological change is incorporated

into factors other than the standard inputs of production. The institutional frame within which industries operate can be a sovereign factor that can radically affect the disembodied technological change. On this basis, reforms that suppress obstacles towards an efficient reallocation of the resources are rather helpful for productivity improvements promoting simultaneously export activity. In the same line of argument, policies that discourage monopoly practices or oligopolistic trusts in the domestic market can boost an industry's productivity by offering a valuable service towards a long-run successful export attitude. From a more general scope, policies that reinforce domestic competition have two facets; they stimulate productivity in the domestic market but they also familiarize domestic producers with the conditions of severe competition already occurred in the international markets.

The second robust result of the present analysis refers to the impact of the domestic market pressure on export performance. This variable, as already discussed, mainly reflects fluctuations of the macroeconomic fundamentals. Policy makers should be aware that an expansionary fiscal policy, for instance, stimulates aggregate demand but destabilises export attitude. If producers face a rapidly increased domestic demand, they seek firstly to fulfil the domestic needs leaving available relatively few resources for export expansion.

The aforementioned analysis does not preclude other factors that drive export performance. On the contrary, the econometric specifications reveal that when industry dummies were included in the model they appeared to be statistically significant identifying an issue of omitted variables. This problem of misspecification suggests that there are still many determinants of export that there are unobserved by the econometrician but important in explaining the variation of the export behaviour. This observation calls for future research in order to enrich our understanding about the forces of export behaviour.

The present study seeks to answer, among others, whether exports are sensitive to productivity changes. Yet, the productivity-exporting nexus has many unexplored aspects. The current index is not appropriate to provide further insights regarding the components affect x -efficiency. For instance,

industries become more productive because either they minimize costs (economic efficiency) or they attain a better allocation of the resources (allocative efficiency). A systematic answer to these issues requires a further decomposition of the TFP measure that is not available in the current non-parametric index.³³ Another issue regarding the relationship between exporting and productivity is that the present analysis does not address systematically the issue of causality. The initial assumption is that any endogeneity bias most likely refers to the contemporaneous values of exports and TFPG. An effective way to tackle this problem, as we do, is to take the lagged values of the right-hand side variables. In case that the nature of the feedback effect from exports to TFPG is longer, then the present OLS estimates yield biased results. The ideal solution for endogeneity problems is the use of an instrumental variable (IV) estimator. Even if an IV estimator is applied, one cannot guarantee that the produced econometric results will be totally unbiased. The IV estimator requires the existence of valid instruments, which implies that instruments should be strongly related to the endogenous variables and uncorrelated with the error terms. The second characteristic is not easily fulfilled since any factor that affects productivity is likely to affect exports as well. A more careful treatment of these issues constitutes a path for further research.

The present study does not investigate export performance and productivity within a comparative framework. This caveat is consistent with an earlier comment concerning the interpretation of TFPG as a proxy of relative prices. The current productivity measure compares performance of the same industry over time while a more accurate measure of relative price would need to compare productivity of a specific industry between Greece and its export partners. Clearly, this exercise is not implemented in this study warning the reader that the estimates of TFPG should be treated with cautiousness when one attempts to interpret them as a measure of relative prices.

³³ The current productivity measure is a Tornqvist index derived from a standard TFP growth accounting approach. Good et al. (1996) develop some useful extensions of this measure based on econometric approaches in order to distinguish between various types of efficiency. An interesting alternative measure is the application of the Malmquist TFP index that provides useful efficiency decompositions.

Appendix A

Table A2.1 Two-Digit Classification

NACE Code	2-Digit NACE Industries
15	Food and Beverages
16	Tobacco products
17	Textiles
18	Apparel and Dyeing of Fur
19	Leather and Footwear
20	Wood and Cork
21	Pulp, paper and Paper products
22	Publishing and Printing
23	Coke and Petroleum
24	Chemicals and Chemical products
25	Rubber and Plastic products
26	Glass products
27	Basic Metals
28	Structural Metal Products
29	Machinery and Equipment
30	Office Machinery and Computers
31	Electrical Machinery and Apparatus
32	Radio, Television and Communication Equipment
33	Medical Precision and Optical Instruments
34	Motor Vehicles Trailers and Semi-Trailers
35	Other Transport Equipment
36	Furniture
37	Recycling

Table A2.2 Summary of Data Sources

Variable	Aggregation	Source
Number of firms	3-digit	NSSG
Value Added	3-digit	NSSG
Output	3-digit	NSSG
Employment	3-digit	NSSG
Full-time Employees		
Hourly-paid Employees		
Unpaid-Family members		
Labour Compensation	3-digit	NSSG
Salaries		
Wages		
Social Security Costs		
Investment	3-digit	NSSG
Land		
Building		
Transport		
Machinery		
Furniture		
Expenditures	3-digit	NSSG
<i>Materials</i>		
Packing		
Raw materials		
Spares		
<i>Energy</i>		
Fuel		
Electricity		
Exports	3-digit	NSSG
Exports to Major Partners	2-digit	OECD-Bilateral Trade Data Base
R&D Expenditure	2-digit	OECD-Science and Technology Indicators
Number of Patents	3-digit	Industrial Property Organisation (IPO)
GDP of Major Partners		World Bank Development Indicators

TableA2.3 Summary Statistics

Variable	Mean	Std. Dev.	Min	Max
Export Ratio (<i>Z</i>)	0.210	2.599	0.002	0.869
<i>TFPG</i>	-0.055	0.192	-1.479	1.340
Machinery per Output (<i>MACH_OUT</i>)	0.149	3.216	0.001	3.075
Industry Business Cycle (<i>IBC</i>)	0.834	1.244	0.201	1.000
Profit Margin (<i>PM</i>)	0.959	2.829	0.000	1.745
R&D Share (<i>RD_Share</i>)	0.008	4.308	0.000	0.650
Domestic Patents (<i>PAT</i>)	3	4	1	51
Foreign Income (<i>D</i>)	340217174	0.002	31626145	1358592020

Notes:

Machinery per output is expressed in thousand drachmas and foreign income is expressed in thousand USD(2000 constant prices)

Table A2.4 Pair-wise Correlation

3-Digit Sample									
	<i>Export Ratio</i>	<i>Exports Growth</i>	<i>TFPG</i>	<i>MAC_OUT</i>	<i>IBC</i>	<i>PM</i>	<i>PR</i>	<i>R&D Share</i>	<i>R&D Personnel</i>
<i>Export Ratio</i>	1.000								
<i>Exports Growth</i>	0.218	1.000							
<i>TFPG</i>	-0.013	0.208	1.000						
<i>MAC_OUT</i>	0.139	0.001	0.101	1.000					
<i>IBC</i>	0.016	0.114	0.401	0.123	1.000				
<i>PM</i>	-0.206	-0.042	-0.078	-0.102	0.049	1.000			
<i>PR</i>	-0.290	-0.042	-0.078	-0.051	0.059	0.740	1.000		
<i>PAT</i>	-0.072	-0.021	-0.040	0.072	-0.020	0.096	0.047		
2-Digit sample									
<i>Export Ratio</i>	1.000								
<i>Exports Growth</i>	0.306	1.000							
<i>TFPG</i>	0.028	0.400	1.000						
<i>MAC_OUT</i>	-0.041	0.035	0.150	1.000					
<i>IBC</i>	0.241	0.207	0.470	0.297	1.000				
<i>PM</i>	-0.240	-0.529	-0.178	0.338	0.047	1.000			
<i>PR</i>	-0.259	-0.392	-0.136	0.346	0.014	0.857	1.000		
<i>R&D SHARE</i>	-0.234	-0.067	-0.211	-0.165	-0.473	-0.025	-0.031		
<i>R&D Personnel</i>	-0.259	0.035	-0.110	-0.349	-0.503	-0.266	-0.261	0.778	
<i>Foreign Income (D)</i>	0.239	0.004	-0.052	0.428	0.161	-0.044	-0.020	0.059	-0.035

Table A2.5 Pavitt Taxonomy

SDOM	2-Digit NACE Code	SCIB	2-Digit NACE Code	SCAI	2-Digit NACE Code	SPEC	2-Digit NACE Code
Food and Beverages	15	Chemicals and Chemical Products	24	Wood and Cork	20	Publishing and Printing	22
Tobacco	16	Office Machinery and Computers	30	Rubber and Plastic Products	25	Machinery and Equipment	29
Textiles	17	Radio, Television and Communication Equipment	32	Glass and Mineral Products	26	Electrical Machinery and Apparatus	31
Apparel and Dyeing of Fur	18	Medical, Precision and Optical Instruments	33	Basic Metals	27	Recycling	37
Leather and Footwear	19			Fabricated Metal Products	28		
Pulp, Paper and Paper Products	21			Motor Vehicles, Trailers and Semi-Trailers	34		
Coke and Refined Petroleum	23			Other Transport Equipment	35		
				Furniture	36		

Notes:

The table shows Pavitt taxonomy only for the 2-digit industrial classification. Industries of the higher disaggregation are classified accordingly. For example, all the 3-digit sub- industries of sector 15 are included into the SDOM group. **SDOM**-Supplier Dominated Group, **SCIB**-Science Based Group, **SCAI**- Scale Intensive Group, **SPEC**-Specialised Suppliers Group

In Pavitt's (1984) taxonomy is given a clear focus on the fact that different principal activities lead to different technological trajectories. From this observation, Pavitt considers that the sources of technical change can be explained by sources of technology, the requirements of users and possibilities for appropriation. This explanation leads Pavitt to classify industries into three categories: supplier dominated, science based and production intensive. The latter group can be further classified into scale intensive and specialised suppliers. The ingredients used by Pavitt for this classification are 2000 innovations conducted by British firms over the period 1945-1979. Ideally, this taxonomy should be perfectly consistent only with the data used by Pavitt. Nonetheless, the wide criteria used in Pavitt's taxonomy allow us to adjust this classification in the present context. Table A2.5 classifies Greek

manufacturing industries relying exclusively on Pavitt's original classification. The underlying causes of technical change in each of these groups can be described as follows:

Supplier dominated industries (SDOM):

These industries can be found in traditional manufacturing activities such as manufacturing of agricultural products, textiles, paper and wood. The main characteristic of these industries is their technological weakness. The latter does not necessarily mean that firms within these industries are technological backward but they do not conduct their own R&D or any other related innovative activity. Innovations used in the firms of this group are derived from their suppliers. Another key characteristic of the SDOM group is that technological trajectories are defined on the basis of cutting costs.

Science Based Industries (SCIB):

This group includes high technology industries. The main characteristic of these industries is that the main source of technical change is R&D intensity, which is mainly conducted within the organisation of the firm. According to Pavitt (1984), these industries can be found in the manufacturing of chemicals and electronics. Firms of this group are also the principal providers of product innovations used in other manufacturing sectors.

Scale Intensive Industries (SCAI):

The emergence of this type of group is resulted from the increased size of the market, which enables firms to reduce costs. In Pavitt's taxonomy the incentive to exploit these scale economies is strong in firms producing three classes of products: standard materials, durable consumer products and vehicles. For the large scale producers, particular inventions are not of special significance. The main

source of technical change in this group is the ability to design, build and operate large scale production processes.

Specialised Supplier Industries (SPEC):

The nature of SPEC group is complementary as the main products of specialised suppliers industries are key components that are used in the production process of other manufacturing activities. With this consideration in mind the industries included in the SPEC group are machinery and related equipment as well as electrical machinery and related apparatus.

Chapter 3

Specialisation, Factor Endowments and Productivity: An Estimation of the Neoclassical Model

3.1 Introduction

Neoclassical trade theory predicts that countries trade with each other due to differences in productivity or factor endowments.³⁴ Differences in productivity are dictated by the classical Ricardian hypothesis, which states that sources of comparative advantage are either labour productivity or unit labour cost differences across countries. The neoclassical trade pattern is supplemented by the factor content approach as attributed to the Heckscher–Ohlin (H-O) theorem, which indicates as main determinants of trade, differences in relative factor endowments.

One can claim that these early developments of international trade theory cannot really be applicable to a complicated global economy. Such a critical claim about the validity of the neoclassical theory seems to ignore the fact that H-O and Ricardo theorems are still the most reliable devices that trade economists use in order to identify the sources of specialisation and trade. Despite the popularity of these models, their empirical assessment presents a number of notable difficulties. The main goal of the present chapter is to contribute to the of research agenda of international trade by assessing the empirical validity of the neoclassical theorems applying evidence from six European countries. The above challenging exercise is carried out in two different stages. At the first stage, the model specified focuses only on the H-O propositions of trade and specialisation while at the second stage; an extended model is specified allowing both H-O and Ricardian forces to determine the pattern specialisation.

The empirical validity of the Ricardian model is documented in some classical studies of Mac-Dougall (1951), Stern (1962) and Balassa (1963). However, evidence regarding the empirical

³⁴ Krugman (1979b) and Markusen (1986) have identified as trade determinants the existence of economies of scale and differences in preferences. The former source of trade demonstrates strong empirical validity (Trefler and Antweiler (2002)) while the latter has been rarely analysed empirically.

validity of the Ricardian idea with recent data is rare because trade researchers tend to consider that the model relies on simplistic assumptions that cannot be met in contemporary global trade. Exceptionally, in studies by Golub and Hsieh (2000) and Choundri and Schembri (2000), the Ricardian hypothesis is revisited concluding that productivity differences still possess an important role in explaining trade flows, although these studies recognise that the model used cannot explain much of the data variation. Two points are of particular interest regarding the above studies; according to Golub and Hsieh (2000), capital and raw materials are almost perfectly mobile internationally, thus the productivity of the labour factor across countries has the strongest influence in determining comparative advantage. This finding adds support to the argument that the Ricardian model has not only a pedagogical content but it can also perform surprisingly well even with more recent data. The second point highlighted in those studies is that there is much variation in the data, which certainly cannot be exclusively explained by the Ricardian proposition. Therefore, the explanatory power of some additional theories should be explored.

Harrigan (2001) in a review paper contradicts the core arguments of the above studies focusing mainly on two aspects. The Ricardian model is indeed simplistic regardless of the fact that capital and raw materials are internationally mobile. According to Harrigan, what matters is how capital and raw materials are allocated between alternative uses and not who owns these factors³⁵. The second aspect refers to Golub and Hsieh's econometric specification in attempting to test empirically the Ricardian idea. Testing the empirical validity of a theory implies that an alternative hypothesis should be stated as a means of comparison, a key element that is absent in Golub's and Hsieh's (2000) work. A precise interpretation of the findings of the Golub's and Hsieh's (2000) study is that an increase in industry's relative productivity can lead to relatively better export performance.³⁶ Certainly, this finding is an interesting contribution to the empirical trade literature

³⁵ The above argument becomes more transparent considering the example of capital stocks and natural resources whose structural use is immobile internationally –even within countries- while their ownership can move very easily.

³⁶ The econometric specification of Golub and Hsieh considers as a dependent variable the relative ratio of exports between the US and its trading partners in good G while the explanatory variable is a ratio of industry's labour productivity in the two countries.

however, the general methodology used to obtain this result can be hardly considered as a feasible test of the Ricardian hypothesis.³⁷

As far as the factor endowments theory is concerned, trade is generated by differences in the relative supplies of factors of production. These differences shape different relative autarky prices and thus the source of trade. H-O trade pattern in a world of two goods, two factors, indicates that a country exports goods produced intensively by its relatively abundant resource. A convenient generalisation of the H-O model in a world with n factors and m goods is described by the following identity: $AT = V - sV^w$ known as the Heckscher-Ohlin-Vanek (H-O-V) theorem. This identity is also known as the factor content of trade and states that a country's vector of net exports (T) adjusted to factor intensities (A) is equal to the difference between the country's factor endowments (V) and the world's factor endowments (V^w) adjusted for the country's consumption share of world endowments (s). This definition has a strong economic intuition, though its empirical implementation presents some notable difficulties. The estimation of the H-O-V prediction requires information in three different observable phenomena, namely factor input requirements as determined by matrix A , factor endowments and trade. While one can easily obtain information for trade flows and factor endowments from national statistics, it is rather difficult to obtain information for the requirements of factor inputs as this presupposes knowledge about a country's specific production function. The choice of a particular production function leads researchers to unrealistic assumptions that cause further problems to the consistency of the H-O-V model.³⁸

Bowen et al. (1987) provides the first assessment of the H-O-V model in a multifactor-multicountry framework. The influence of this study is of special importance in the field, though its conclusions are rather discouraging for the empirical performance of the model. Their findings suggest that H-O-V provides no better prediction than a coin flip about which factor's output a

³⁷ Harrigan emphasises that the true equilibrium effect of the Ricardian proposition is that better productivity in one sector "hurts" export performance in another sector (p.28); however, such a hypothesis is not easily testable and thus most of the evidence is silent about cross-industry productivity differences.

³⁸ The H-O-V model is the benchmark model used in Leamer (1984), which assumes that matrix A is common for all countries thus playing no role on the pattern of trade. This assumption is equivalent to consider identical technology across countries, which is itself an assumption that constitutes a crucial debate on the literature of international trade.

country exports. As mentioned above the empirical assessment of the H-O-V theorem relies on the assumptions of identical factor requirements, equal factor prices, and homothetic consumption preferences across countries. Trefler (1995) confirms the above results about H-O-V theorem and investigates further, why data have systematic deviations from the theory. Trefler (1995) explores the validity of the H-O-V considering that productivity differences are country specific. Trefler concludes that this reformulation of the original model offers a better fit with actual data. Similarly, Davis and Weinstein (2001b) and Lai and Zhu (2006) investigate whether technological differences are industry Hicks-neutral or country Hicks-neutral. The former study shows that after relaxing some of the assumptions of the H-O-V theorem, the model performs quite well with international trade data.

Another strand of the trade literature analyses the pattern of specialisation within a neoclassical framework applying a static approach. The static approach, known as the Rybczynski effect, refers to the linear relation between the sectoral output and the aggregate factor endowments. This is that accumulation of a factor increases the output of the industry that uses intensively that factor. Within this framework, Harrigan (1995) investigates the source of comparative advantage in twenty OECD countries. A crucial assumption of his analysis is that free trade equalises prices of goods and as a result the factor prices are also equalised. According to Harrigan's argument, the presence of Factor Price Equalisation (FPE) is sufficient to lead to the assumption that a country's output is a linear function of national factor endowments. Harrigan's (1995) findings are consistent with Bowen et al. (1987) regarding the poor explanatory power of H-O-V. Harrigan (1997) enriches the neoclassical model of specialisation using a translog approximation to the revenue function in order to estimate industry's output as a function of factor endowments and specific technological differences across countries. The empirical representation of Harrigan's (1997) model takes a form very similar to the linear Rybczynski equation. The main message from this study is that both factor endowments and productivity differences are important determinants of specialisation.

The present chapter is divided mainly in two sections. The first section estimates a model based on the Rybczynski effects of specialisation. As one can understand from the previous discussion the Rybczynski prediction represents a general equilibrium effect. In the simplest version of the model without technological differences across countries, national factor supplies are the sole determinants of specialisation. The key hypothesis tested in the first section of the chapter is whether industry's output can be explained by changes in national factor endowments. The evidence applied to test this hypothesis is obtained from six European countries, namely France, Germany, Greece, Italy, Spain and UK. Since the Rybczynski equation is widely recognised as the testable version of the H-O model then it should work quite well both with production and with trade data. The trade version of the Rybczynski effect is applied for the case of Greek bilateral trade considering as partners the remaining countries of the sample.

The second section of the chapter introduces the Ricardian technological differences as sources of specialisation. The empirical literature so far suggests that any of these theories has its own role on predicting the pattern of trade (or equivalently the pattern of specialisation) but none of them alone is sufficient to explain the entire pattern of trade. The present study seeks to contribute to the agenda by applying a joint model, initially developed by Harrigan (1997). Applying a joint model, though, has some obvious difficulties. There is a tendency in international trade studies to view H-O and Ricardian explanations as independent from each other. However, in empirical studies, this assumption needs further investigation otherwise the use of both H-O and Ricardian forces in the same model might generate misspecified results about the pattern of specialisation.

In a capital-abundant country, industries that use this factor intensively acquire a comparative advantage but national capital abundance is likely also to affect industries' productivity. The reason why the H-O propositions are likely to bias the contribution of Ricardian forces to the patterns of specialisation is due to the failure of factor price equalisation (FPE). If factor rewards are not equalised across countries then industries find it more beneficial to substitute the relatively expensive factor with the cheaper one. Under standard assumptions, it is widely accepted that

differences in relative factor rewards are driven by differences in relative factor supplies. From these considerations, the following link is emerged: capital abundant countries are biased towards capital services in all industries. This process can lead capital-abundant countries to have higher relative productivity in all industries. This argument can be supported by the principles of endogenous growth theory in which technological progress- the main stimulus of productivity growth- is embodied in the use of sophisticated capital inputs.³⁹

The above issue is carefully addressed by examining to what extent national factor endowments drive factor mixes at the industry level. Once the above problem is mitigated, the next step is to estimate a joint model quantifying the contribution of each force to the pattern of specialisation. The chapter is organised as follows, section 3.2 presents an analytical framework of the sources of specialisation. This framework builds upon a translog revenue function, which is simplified in steps leading to an estimatable Rybczynski equation, which is the main empirical vehicle throughout the chapter. Section 3.3 discusses briefly some data sources and relevant issues. Section 3.4 estimates the Rybczynski regressions for both the pattern of specialisation and trade. Section 3.5 is devoted to estimate various specifications of a joint model including both H-O and Ricardian factors. This section also presents the method used to construct the productivity index as well as the test conducted to identify whether the H-O and the Ricardian model are correlated with each other. Section 3.6 concludes with main policy implications derived from the analysis carried out in the chapter.

³⁹ The accumulation of capital is the key factor led to industrial innovation and such a view is particularly supported by formal models of Romer (1990), Aghion and Howitt (1992) and Grossman and Helpman (1994). Additionally, Baumol et al. (1989) report some evidence that supports the high correlation between Total Factor Productivity growth and annual growth rates of capital-labour ratios.

3.2 Sources of Specialisation

A convenient way to demonstrate the sources of specialisation within a neoclassical framework is to follow the approach of the revenue function that Dixit and Norman (p.31 (1980)) initially suggest and Harrigan (1997) empirically assesses. The key characteristic of this analysis is that national income can be expressed as a function of factor endowments and final good prices.

$$Y = r(P, V) \quad (3.1)$$

P is a vector of prices and V is a vector of national factor endowments. The revenue function is homogeneous of degree one in P and V . Under the assumptions that the revenue function is continuous and twice differentiable, the gradient of (3.1) with respect to prices gives the amount of output that maximises the national income. Assuming that technology is identical across countries then specialisation across countries is determined exclusively by the differences in P and V . However, a large number of studies reveal that there are significant productivity differences across countries (Dollar and Wolff (1993), Harrigan (1999), O'Mahony and Van Aark (2003)). To include the technological factor in the model, it is required to make some plausible assumptions about how technology differs across countries.

Trefler (1995) models technological differences as being sector neutral and country specific. This formulation, as discussed earlier, allows us to adjust factor endowments in productivity units in the HOV equation but it does not explain how technological differences affect comparative advantage. Instead, the present framework follows Harrigan's (1997) methodology and formulates technology differences as industry specific and country neutral. Consider the technological parameter $\theta_{i,c,t}$ for industry i in country c at year t . If changes in this parameter reflects Hicks-neutral technical change then with the same amount of inputs, industry i in country c at year t becomes θ times more productive than a reference country. The attractive feature of this productivity formulation is that technological differences can be measured with the use of a standard Total Factor Productivity (TFP) index.

The technological parameter θ can be introduced directly into (1) thus the revenue function is re-expressed as⁴⁰:

$$Y = r(\Theta P, V) \quad (3.2)$$

where $\Theta = \text{dia}\{\theta_1, \dots, \theta_I\}$ is a diagonal matrix that includes the Hicks-neutral technological parameters of industries $i \dots I$. In industry i , the differentiation of (3.2) with respect to θ_i establishes the elasticity of industry i 's output after a change in technical efficiency:

$$\tilde{x}(\theta p_i, V) = \frac{\partial r(\theta_i p_i, V)}{\partial \theta_i} \quad (3.3)$$

The next step is to derive an empirical expression for the revenue function $r(\Theta P, V)$. Following Woodland (1980, 1982), Kohli (1991) and Harrigan (1997), the revenue function can be adequately approximated by using a second order translog function. The specific form of the revenue function becomes:

$$\begin{aligned} \ln r(\theta p, V) = & \beta_{00} + \sum_i \beta_{0i} \ln \theta_i p_i + \frac{1}{2} \sum_i \sum_k \beta_{1i,k} \ln \theta_i p_i \ln \theta_k p_k + \sum_j \beta_{2j} \ln V_j + \\ & \frac{1}{2} \sum_j \sum_m \beta_{2j,m} \ln V_j \ln V_m + \sum_i \sum_j \beta_{3i,j} \ln \theta_i p_i \ln V_j \end{aligned} \quad (3.4)$$

where the summations in i and k refer to industries and run from 1 to I and the summations j and m refer to factor endowments and run from j to J . By assuming symmetry of cross effects then it is implied that: $\beta_{i,k} = \beta_{k,i}$ and $\beta_{j,m} = \beta_{m,j}$. Similarly, the linear homogeneity restriction in the revenue function requires:

$$\sum_i \beta_{0i} = 1, \sum_j \beta_{2j} = 1, \sum_j \beta_{1i,k} = 0, \sum_m \beta_{2j,m} = 0, \sum_i \beta_{3i,j} = 0$$

Differentiating (3.4) with respect to p_i one can obtain industry i 's output share to GDP⁴¹ :

⁴⁰ If one follows Trefler's (1995) approach in modeling technological differences, then the assumption of homogeneity implies that the revenue function is written as: $Y = \Theta r(P, V)$. This formulation suggests that a positive technological shock increases output in all industries thus affecting national absolute rather than comparative advantage.

$$s_i = \beta_{0i} + \sum_k \beta_{1i,k} \ln \theta_k p_k + \sum_j \beta_{3i,j} \ln V_j \quad \text{or}$$

$$s_i = \beta_{0i} + \sum_k \beta_{1i,k} \ln \theta_k + \sum_k \beta_{1i,k} p_k + \sum_j \beta_{3i,j} \ln V_j \quad (3.5)$$

Equation (3.5)⁴² states that industry i 's output share (s) to country's GDP is a function of technology, prices of final goods and factor endowments. Supposing that trade equalises prices of final goods across countries (i.e. free trade)⁴³ then (3.5) - after adding country and time subscripts- becomes:

$$s_{i,c,t} = \beta_{0i,c} + \rho_{i,t} + \sum_i \beta_{1i} \ln \theta_{i,c,t} + \sum_j \beta_{3j} \ln V_{j,c,t} ,$$

$$\text{where } \rho_{i,t} = \sum_i \beta_{1i} p_{i,t} \quad (3.6)$$

If technology is identical across industries within a country (i.e. $\ln \theta_{i,c,t} = \ln \theta_{c,t}$), then the second summation in equation (3.6) can be substituted by a set of country and year fixed effects. In this case, the pattern of specialisation depends exclusively on factor supplies:

$$s_{i,c,t} = \beta_{0i,c} + \rho_{i,t} + \lambda_{c,t} + \sum_j \beta_{1j} \ln V_{j,c,t} \quad (3.6a)$$

Equations (3.6) and (3.6a) are the conceptual equations upon which we develop the empirical analysis of the following sections. Equation (3.6) represents an extended version of the Rybczynski effect allowing for an industry specific technology. Equation (3.6a) represents the strict version of the Rybczynski effect, which states that at constant prices, an increase in the supply of a factor will lead to an increase in the industry's output that uses intensively that factor and a reduction in the output of the other industries.

⁴¹ Cadot et al. (2007) represent in detail how the homogeneity restrictions provided above can be reformulated in order to express all the determinants of specialisation relative to a reference value. In the empirical model of the present chapter national factor supplies are normalised relative to each country's endowment of labour.

⁴² Since equation (3.5) is derived from a translog approximation then it holds for all countries and time periods.

⁴³ This issue becomes more complicated if one assumes that there are many no-traded goods in the economy and thus prices are not equalised via trade. There is no information for prices in the non-traded sector and thus it is quite difficult to incorporate these elements into the analysis. An alternative view is to consider price effects as country specific controlling for them using country dummies.

3.3 Data Sources

The data used in the present analysis refer both to the industry and country level. The industry level data concentrate on output shares, trade flows, and various measures of industrial performance. The study includes 6 countries, France, Germany, Greece, Italy, Spain and UK and covers activities of 13 manufacturing industries. Output share is measured as industry i 's share to country c 's value added and data are taken from OECD-Structural Analysis (STAN) (ISIC Rev.3) for the period 1987-2003. Data on Greek trade flows are obtained from the OECD bilateral trade database and refer to export-import flows of these manufacturing industries for the period 1988-2004. OECD-STAN provide data on industrial performance that cover value added, employees, labour compensation and gross fixed capital formation (see Table B3.2 in Appendix B for a full summary of data sources).⁴⁴ The piece of industrial information obtained from STAN is utilised to construct the TFP indices.

The set of economy-wide factor supplies includes land, energy, fixed capital and three types of labour. These data are taken from the World Bank Development Indicators. Land is measured in hectares of arable land, energy factor includes production of energy sources converted into oil equivalent, and capital formation includes purchases of fixed assets (i.e. land improvements, plant, machinery, equipment purchases and investment in construction of infrastructure). Labour data are classified workers into three different groups according to the educational level: (1) the share of labour force with primary education, (2) the share of labour force with secondary education and (3) the share of labour force with tertiary education. In the empirical estimation, the shares of workers with primary and secondary education are aggregated to a single group referred to as the less skilled labour and the third group represents the skilled labour.

Appendix B3.1 at the end of the chapter provides a discussion about the various problems encountered in the construction of the variables used in the empirical analysis. Table (3.1) displays average values of relative factor endowments for the six countries. All factor supplies are expressed

⁴⁴ For the industry level variables, STAN reports deflators for value added and capital; these deflators are applied to convert nominal values to real ones.

relative to aggregate labour. The table verifies some common beliefs regarding factor abundance in Europe but also points out some new interesting remarks. Germany is the most capital abundant country of the sample and probably the most capital abundant country in Europe whilst, as expected, Greece has the lowest capital-labour ratio. The pattern is slightly different in the relative abundance of skilled labour in which UK is the leading country. The scarcest country in skilled labour is Italy with a 9.2% percent of the total labour force to possess a degree from tertiary education. More distinguishable are the differences regarding abundance of arable land. Spain, France and Greece are those countries with the highest ratio of arable land per worker while UK presents the lowest ratio.

Table 3.1 Relative Factor Endowments (1987-2003)

Country	<i>K/L</i>	<i>SL/L</i>	<i>A/L</i>	<i>E/L</i>
France	34,420	0.207	0.718	0.005
Germany	35,596	0.182	0.300	0.004
Greece	16,867	0.202	0.630	0.002
Italy	34,191	0.092	0.364	0.001
Spain	25,669	0.184	0.859	0.002
UK	26,657	0.222	0.213	0.008

Notes:

K/L is capital stock per worker. Capital is constructed via an inventory perpetual method identical to this used in Chapter 2 of the thesis and it is expressed in constant 2000 US dollars. *SL/L* is the percentage share of workers with at least a degree from tertiary education over the total number of workers. *A/L* are hectares of arable land per worker. *E/L* is KG of oil equivalent per worker. Ratios refer to average values over the whole period. More details about the sources of the variables can be found in Appendix B3.2

Table (3.2) reports the percentage share of total manufacturing value added in GDP and the share of each industry's value added in total manufacturing for all six countries in the sample. A common feature of all countries is that the share of total manufacturing in GDP declines in the period under study. The rate of decrease varies substantially across countries, the most rapid decrease is observed in UK, which is 36% percent between 1988 and 2002. Except for the share of the textiles industry that declines substantially for all countries, it is difficult to draw a clear pattern regarding the movements of value added share in total manufacturing. Greece experiences the largest decrease in the share of this industry, which is 32.4% in 1988 and decreases to 15.7% in 2002, indicating a declining rate of 51%.

Table 3.2 Value Added Share of Manufacturing Industries to GDP

Industry	Time Period	France	Germany	Greece	Italy	Spain	UK
Food	Average	14.25	8.91	21.00	10.37	16.21	13.81
	1988	13.30	7.90	16.10	9.70	16.90	13.00
	2002	14.90	9.30	21.70	10.90	14.40	14.20
Textiles	Average	5.60	3.09	22.97	14.38	8.36	5.38
	1988	7.20	4.40	32.40	15.60	10.10	6.80
	2002	4.30	2.10	15.70	12.70	6.80	3.80
Wood	Average	1.70	1.89	2.91	2.72	2.55	1.53
	1988	1.60	1.50	2.70	2.60	2.60	1.70
	2002	1.60	1.70	2.20	2.90	2.40	1.70
Pulp and Paper	Average	8.47	7.55	6.74	6.56	8.15	12.53
	1988	8.20	7.00	5.50	6.10	7.40	11.30
	2002	8.30	7.50	8.30	7.10	9.10	13.80
Coke and Petroleum	Average	2.87	0.84	4.48	1.77	2.80	2.03
	1988	2.20	0.80	2.50	1.20	3.20	2.30
	2002	3.50	1.10	7.60	0.90	2.90	1.70
Chemicals	Average	10.19	10.05	5.78	7.98	8.89	10.54
	1988	9.30	11.50	5.20	8.30	9.00	10.80
	2002	11.10	10.10	5.60	8.30	9.20	10.90
Plastics	Average	4.56	4.76	2.63	4.04	4.44	4.96
	1988	4.80	4.30	2.30	3.60	3.80	4.20
	2002	4.40	5.00	2.80	4.20	5.00	5.30
Other non-Metallic	Average	4.91	4.01	6.56	6.30	7.65	3.53
	1988	5.10	3.80	5.80	6.10	7.50	4.10
	2002	4.70	3.30	8.30	7.00	8.10	3.60
Basic metals	Average	13.29	13.06	9.46	13.89	12.05	11.09
	1988	13.30	13.00	12.20	14.00	12.20	12.10
	2002	12.90	13.00	9.10	13.30	13.50	10.10
Machinery	Average	7.77	14.59	2.97	11.57	6.33	8.41
	1988	8.60	14.20	2.40	11.20	5.90	8.40
	2002	6.70	15.30	3.30	12.40	7.20	8.20
Electrical	Average	11.67	14.70	3.29	9.48	7.41	12.38
	1988	12.40	16.30	2.70	9.90	7.50	12.50
	2002	10.40	13.50	3.80	9.00	6.50	11.40
Transport	Average	10.76	13.53	4.53	6.08	10.73	10.24
	1988	9.60	12.50	3.50	6.70	9.80	9.80
	2002	13.50	15.40	5.80	6.30	10.40	10.80
Other Manufacturing	Average	4.09	2.99	6.69	4.85	4.37	3.59
	1988	4.40	3.00	6.50	4.90	4.00	2.80
	2002	3.70	2.70	5.90	5.00	4.50	4.50
Share of the Total Manufacturing Sector to GDP	Average	18.84	24.36	13.39	21.59	18.87	19.72
	1988	21.10	29.80	16.60	24.70	22.30	23.70
	2002	17.80	22.30	11.50	19.50	16.70	15.20

Notes:

Industry names follow ISIC (Rev 3) classification. Numbers represent percentage points.

As already mentioned the trade version of the specialisation model is assessed in Greek bilateral trade. This empirical exercise focuses on trade flows only with the remaining five countries

of the sample (France, Germany, Italy, Spain and UK). The selection of these countries is not based on random criteria as flows from (and to) these countries account on average for the 75% and 84% of total imports and exports from (and to) EU-15. Greek trade with these countries is also large compared to the total trade, specifically imports and exports from (and to) these countries cover the 51% and 47% of Greek imports and exports from (and to) the rest of the world. Table B3.3 in Appendix B presents average trade shares with each of these partners.

3.4 Specialisation and Factor Endowments

This section presents an estimatable version of equation (3.6a), which highlights the Rybczynski effects of specialisation. Despite the simplicity of the Rybczynski equation, this model remains among the most popular devices used to identify the structure of production and the pattern of trade. Two potential problems are encountered regarding the empirical representation of (3.6a). The first is that factor endowments are not adjusted in productivity units and thus one can claim that might produce mis-specified results regarding the contribution of H-O forces to determining specialisation. In the current framework, this problem is easily overcome, because productivity differences are assumed to be industry specific and as such, they are modelled separately.⁴⁵ The second problem is that the original Rybczynski specification does not express factor supplies in a relative manner, as it is required from the H-O theory. Imposing the homogeneity restriction in equations (3.6) and (3.6a), we can address the problem of scaling by expressing all factor supplies relative to labour (see also footnote 43).⁴⁶

Summarising the above discussion, the estimatable version of (3.6a) is as follows:

$$s_{i,c,t} = \beta_{0i,c} + \beta_1 \log\left(\frac{K}{L}\right)_{c,t} + \beta_2 \log\left(\frac{SL}{L}\right)_{c,t} + \beta_3 \log\left(\frac{A}{L}\right)_{c,t} + \beta_4 \log\left(\frac{E}{L}\right)_{c,t} + u_{i,c,t} \quad (3.7)$$

⁴⁵ This task is carried out in section (3.5), which uses industry-specific productivity indices as a proxy for the technology parameter θ .

⁴⁶ Fitzgerald and Hallak (2004) re-scale the Rybczynski equation to nest the obvious alternative hypothesis that industry i 's output level depends on country c 's size. Given that the present framework is based on a log-linear translog approximation to the revenue function this transformations is not necessary.

The dependent variable is industry i 's output share (s) in country c 's GDP at year t . The right hand side consists of four nation-wide factor endowments of capital (K), skilled labour (SL), arable land (A) and energy (E), which all have expressed relative to total labour (L). This slightly modified version of the Rybczynski theorem is also met in Fitzgerald and Hallak (2004)-though without the energy endowment-and it carries many similarities with the specification of Harrigan (1995), Redding (2002) and Reeve (2006), offering a useful basis for comparing our results.

Equation (3.7) tests the Rybczynski effects with production data implying that industry i 's share output is a function of relative national factor endowments. To provide a more direct test of the Rybczynski effects with reference to trade, equation (3.6a) is also tested for the case of Greek bilateral trade. To implement this task, an additional assumption is necessary to ensure that demand conditions between trading partners are identical, that is, residents in countries involved in trade exhibit common preferences. On this base, industry i 's net output⁴⁷ is equal to industry i 's net exports. This specification is tested with particular interest in Greece's bilateral trade with France, Germany, Italy, Spain and UK. The trade specification is written as:

$$\log\left(\frac{X_{i,h,f,t}}{X_{i,f,h,t}}\right) = v_i + \sum_{j=1}^4 \gamma_{i,j} \left(\frac{V_{j,h,t}}{V_{j,f,t}}\right) + u_{i,h,f,t} \quad (3.8)$$

Equation (3.8) expresses trade from a bilateral standpoint. On the left-hand side, we have the ratio of bilateral exports (X) in industry i between Greece, always indexed as h and Greece's trading partner indexed as f . The right-hand side of (3.8) includes the same sum of relative factor endowments as in (3.7) but the relative factor endowments in country h are now expressed relative to the factor endowments of the trading partner f . Intuitively, this specification tests whether industry i 's net exports are associated with changes in the bilateral relative factor endowments.

Equation (3.7) is estimated after pooling data across countries and years. Table (3.3) reports results from a Seemingly Unrelated Regression (SUR) for each industry. Strong inference can be made for capital and energy intensity. The ratio of capital-labour (K/L) is positive in ten out of

⁴⁷ Industry's net output is defined as production minus domestic consumption.

thirteen industries and in eight of them is statistically significant at conventional levels; such a result is consistent with the key stylised facts revealed in other studies supporting evidence regarding the positive role of capital on manufacturing's output (Harrigan (1995)). The energy-labour (E/L) ratio appears with a positive sign in ten out of the thirteen industries and it is frequently statistically significant (i.e. in six industries). No particular conclusion can be drawn for the remaining two factor endowments, namely skilled labour and arable land. Their impact on industries' output share is not clearly specified and most crucially, coefficients of these factors are statistically insignificant in most of the cases.

Table 3.3 SUR Estimates of Equation (3.7)-Industry Output Shares as a Function of National Factor Endowments

Industry	K/L	SL/L	A/L	E/L	N	R-squared
Food	0.503** (2.21)	-0.118 (-0.63)	-0.624 (-1.30)	0.723*** (2.75)	88	0.95
Textiles	0.982*** (3.51)	-0.22 (0.95)	-0.486 (0.83)	0.702** (2.17)	88	0.93
Wood	-0.006 (0.031)	0.749*** (4.62)	0.329 (0.80)	-0.337 (1.49)	88	0.87
Pulp and Paper	0.783*** (2.84)	-0.181 (0.79)	-0.702 (1.21)	0.587* (1.84)	88	0.92
Coke and Petroleum	0.772 (1.43)	0.386 (0.86)	-2.325** (2.05)	0.682 (1.09)	88	0.91
Chemicals	1.229*** (2.79)	0.502 (1.38)	-1.061 (1.14)	1.092** (2.15)	88	0.94
Plastics	0.750** (2.20)	0.29 (1.03)	-0.0491 (0.068)	0.434 (1.10)	88	0.94
Other non-Metallic	0.541*** (3.50)	-0.219* (1.72)	0.144 (0.44)	0.688*** (3.86)	88	0.84
Basic Metals	-0.550*** (4.09)	0.187* (1.68)	1.006*** (3.55)	-0.443*** (2.85)	88	0.76
Machinery	0.345 (1.27)	-0.167 (0.74)	0.989* (1.73)	0.0525 (0.17)	88	0.95
Electrical	0.767*** (3.36)	-0.156 (0.82)	0.596 (1.24)	0.544** (2.06)	88	0.85
Transport	0.280* (1.83)	0.197 (1.55)	-0.728** (2.25)	0.193 (1.09)	88	0.96
Other Manufacturing	-1.351*** (2.59)	1.599*** (3.71)	0.652 (0.60)	-1.972*** (3.28)	88	0.66

Notes:

The estimation method used in the table is Seemingly Unrelated Regression (SUR). Absolute t-values are shown in parentheses. The asterisks correspondence is *significance at 10%; **significance at 5%; ***significance at 1%. All regressions include year and country dummies (not shown)

Results from the Rybczynski regression with trade data (i.e. equation (3.8)) are reported in Table (3.4). The same procedure is followed, data are pooled across trading pairs and years and results reported for each industry using the SUR estimation. There is an expected radical change in the sign of capital abundance, which confirms the different pattern of production structure between Greece and its trading partners. The coefficient of the capital-labour ratio is consistently negative and frequently statistically significant. On the contrary, the estimated coefficient of arable land appears positive and statistically significant in five industries. For skilled labour and energy abundance, it is quite difficult to sketch a conclusive pattern since the associated estimated coefficients vary across industries and frequently appeared statistically insignificant. These results

have a clear economic interpretation that an increase in capital abundance is a negative determinant of Greek trade flows. However, equations (3.7) and (3.8) are mis-specified if one seeks to interpret them in line with the propositions of the H-O theory.

Table 3.4 SUR Estimates of Equation (3.8)-Greece's Trade as a Function of Bilateral Relative Factor Endowments

Industry	R.K/L	R.S/L/L	R.A/L	R.E/L	N	R-squared
Food	0.213 (0.31)	-2.545** (2.34)	-3.586*** (2.79)	3.013*** (3.54)	75	0.79
Textiles	-1.691*** (4.54)	0.569 (0.95)	-2.951*** (4.17)	0.139 (0.30)	75	0.95
Wood	-0.242 (0.14)	-4.225 (1.48)	-5.799* (1.71)	3.758* (1.68)	75	0.68
Pulp and Paper	0.801 (0.78)	2.231 (1.34)	6.972*** (3.55)	-0.763 (0.59)	75	0.59
Coke and Petroleum	8.878*** (2.97)	-2.478 (0.52)	11.36** (2.00)	2.679 (0.71)	75	0.54
Chemicals	-1.939*** (3.27)	-0.717 (0.75)	-0.0698 (0.062)	0.937 (1.26)	75	0.69
Plastics	-1.636*** (3.53)	0.777 (1.04)	2.422*** (2.74)	0.0738 (0.13)	75	0.88
Other non-Metallic	-1.892*** (2.72)	2.935*** (2.62)	5.673*** (4.28)	-2.536*** (2.90)	75	0.78
Basic Metals	-1.151 (1.52)	-1.12 (0.92)	2.683* (1.87)	-0.482 (0.51)	75	0.58
Machinery	-1.208** (2.10)	2.114** (2.29)	4.598*** (4.21)	-1.599** (2.21)	75	0.86
Electrical	0.953 (1.26)	-1.07 (0.88)	-1.411 (0.98)	0.0361 (0.038)	75	0.67
Transport	2.224 (1.57)	-1.125 (0.49)	-3.532 (1.31)	4.045** (2.28)	75	0.59
Other Manufacturing	-1.954*** (4.00)	-2.197*** (2.79)	-0.818 (0.88)	1.483** (2.41)	75	0.87

Notes:

Right-hand side variables of equation (3.8) are relative (R) factor endowments of Greece vis-à-vis that of the importing country. The estimation method used in the table is Seemingly Unrelated Regression (SUR). Absolute t-values are shown in parentheses. The asterisks correspondence is *significance at 10%; **significance at 5%; ***significance at 1%. All regressions include year dummies (not shown)

To interpret the above results more tightly with regard to the H-O predictions some insightful information is required regarding the intensity of the above factors at the industry level. It should be noted that the validity of H-O theory in the literature is tested with the use of sign and rank tests that they are in principal non-parametric techniques (James and Elmslie (1996)). These tests are quite restrictive since they provide clear trade predictions only in the case of a two good-two factor model. If the analysis involves a higher dimensionality with more factors and industries, the H-O predictions are not straightforward. To draw some inference for the validity of the H-O theory it is

necessary to match national factor abundance with factor intensity at the industry level. Table (3.5) reports mean values of capital and energy intensity ratios at the industry level over all countries and years. Data for capital and energy intensity at the industry level are taken from the OECD-STAN and GGDC-KLEMS databases, respectively. Panel *A* shows capital-labour ratios for the whole sample, for Greece and for Greece's trading partners, respectively. Panel *B* shows energy intensity ratios for the whole sample only.⁴⁸ Both panels rank industries in accordance to their factor intensity.

The interpretation is initially focused on industries of Table (3.3) that have a negative and statistically significant coefficient of capital abundance, namely basic metals and other manufacturing. These estimated coefficients of factor endowment match quite well the actual capital intensity of these industries since both of them are quite low in the associated ranking (Panel *A*). Industries with a negative estimated and statistically significant coefficient of energy-labour are again basic metals and other manufacturing. The latter is placed last in the corresponding ranking while the former is in the middle. Turning to industries with a positive estimated coefficient of energy-labour, namely chemicals and other non-metallic, their associated ranking in Table (3.5) is high verifying the positive link between the estimated impact of national factor endowments and the actual factor intensity.

Comparing capital intensity of Greece's industries with those of its trading partners in panel *A*, it is clearly indicated that Greece uses this factor less intensively in all industries. Based on this, the negative estimates of capital-labour ratios in Table (3.4) are perfectly consistent with the propositions of the H-O theory. Unfortunately, there is no information about actual intensity of arable land at the industry level and thus it is impossible to check whether the positive estimated coefficients are in harmony with the actual intensity.

Overall, the present analysis- after using both production and Greek trade data -suggests that the mechanisms of H-O theory are at work. Building the empirical analysis upon the Rybczynski

⁴⁸Energy intensity data for Greek manufacturing industries are not available. Only data for capital intensity are reported.

general equilibrium effects, remarkable evidence comes on surface based on the sources of specialisation and the validation of the H-O model. The main intuitive idea behind these findings is that an increase in the abundance of a factor reinforces comparative advantage in the industry that uses intensively that factor. Analysing the pattern of specialisation within a Rybczynski framework seems to perform equally well in a bilateral trade context at least as far as the case of Greece is concerned. The robust estimates produced for the Greek trade with five European partners imply a more vital implication regarding the power of H-O model in explaining the sources of trade flows. That is, the larger the differences are in factor abundance between trading partners, the better is the performance of H-O. Recent studies of Debaere (2003) and Lai and Zhu (2006) have also confirmed this intuitive result.

Table 3.5 Average Factor Intensity by Industry (1988-2002)

Panel A				Panel B	
Industry^A	Capital Intensity^B- Entire Sample	Capital Intensity- Greece	Capital Intensity- Trading Partners	Industry	Energy Intensity^C Entire Sample
Coke and Petroleum	195.29	14.99	231.35	Coke and Petroleum	298.38
Electrical	140.12	6.53	166.84	Chemicals	31.46
Transport	124.88	2.53	150.36	Plastics	26.88
Chemicals	102.76	12.16	120.88	Other non-Metallic	14.54
Machinery	74.18	0.39	88.94	Electrical	9.24
Plastics	74.12	3.07	88.33	Basic metals	5.08
Pulp and Paper	72.89	2.06	87.05	Wood	4.37
Other non-metallic	69.33	3.52	82.49	Machinery	4.04
Basic metals	62.36	3.41	74.15	Transport	3.68
Food	54.89	5.02	64.87	Food	3.40
Wood	41.33	3.61	50.76	Pulp and Paper	2.80
Other	37.91	11.42	43.21	Textiles	2.03
Manufacturing				Other	
Textiles	25.42	5.80	29.35	Manufacturing	1.79

Notes:

- A. Industries are in descending order according to their factor intensity
- B. Capital intensity is measured as the ratio of capital stock per employee. Capital stock is constructed via a perpetual method, (see next section for more details) from data on fixed capital assets reported by OECD-STAN
- C. Data for intermediate energy inputs are taken from GGDC-KLEMS and energy intensity is the ratio of energy inputs per employee

3.5 Technology Differences and Specialisation

The Rybczynski equation (3.6a) represents a general equilibrium linkage between changes in the mixes of endowments and changes in the mixes of output. This model is silent about the equilibrium effect of technology on changes in the pattern of specialisation.⁴⁹ Nevertheless, a scenario that systematically excludes productivity as a potential source of specialisation should be viewed as incomplete if we take into account that a marked outcome from international productivity studies is that productivity differences across countries are large. This outcome implies that productivity differences may have a strong impact on specialisation and thus their role should be carefully addressed.⁵⁰ Returning to the original specification (3.6), the technological parameter θ represents the role of technology. The crucial issue is how to model these productivity disparities. Trefler (1995, 2002) adjusts the factors of production in productivity units in such a manner that technology matters for country's absolute rather than comparative advantage. The present study follows Harrigan's methodology (1997) and approximates technology parameter θ by using Hicks-neutral TFP indices that they vary across countries industry and time.

Including productivity in the present framework, the resulting specification is a unified model that considers both Heckscher-Ohlin and Ricardo as sources of specialisation. The empirical estimation of the unified model presupposes that some key issues are clarified so as to obtain clear predictions about the sources of specialisation. A crucial attribute of the Ricardian model is that productivity is taken as exogenously determined. This consideration is convenient for the initial exposition of the model however, when one estimates a joint specification, the a-priori assumption of exogenous technology is at least ambiguous.

⁴⁹ It should be made clear at this point, that the terms "technology" and "productivity" have actually the same meaning. Given that, the productivity index represents the technical efficiency parameter of the production function.

⁵⁰ See for reference, Dollar and Wolff (1993), McKinsey (1993), Harrigan (1999) and Golub and Hsieh (2000).

In fact, one can argue that H-O and Ricardo theorems are likely to be interrelated with each other. As discussed in the introduction, the endogenous approach of economic growth regards that technological improvements are associated with national factor endowments and more specifically with the accumulation of physical and human capital. This view accords well with the idea that a capital abundant country is likely to be more productive in all industries than a less-capital abundant country simply because it has the opportunity to substitute labour inputs with more advanced capital techniques. Similarly, if human capital affects productivity performance positively then a country relatively well endowed in skilled workers is able to experience superior productivity in all industries. If the above mechanisms are at work, then national factor endowments are correlated with sectoral productivity; thus the estimation of a unified model will not provide clear indications for the contribution of H-O and Ricardian models to the pattern of specialisation.⁵¹

This section works through an empirical test to detect whether national factor endowments have feedback effects on industry's productivity and then estimates a joint model. Before proceeding with the above tasks, it is necessary to describe the construction of TFP and clarify key issues related to the measurement of the variables.

⁵¹ Assume a capital abundant country in which TFP is the key determinant of specialisation in capital – intensive industries while the national relative capital abundance is of minor importance. Paying no attention to the possible scenario that factor abundance drives TFP at the disaggregate industry level; economists will tend to believe that Ricardian forces is what really matters for an industry's comparative advantage. However, this is a misleading argument if the true effect is that high productivity performance is driven by the fact that the mix of industry's inputs is biased towards capital due to country's capital abundance. Morrow (2006) makes the above argument more transparent illustrating an example with US and China. US have the largest world share in the supply of aircrafts while China possesses the highest world share in the supply of textiles. It is reasonable to assume that the most productive industry in US is the aircraft industry while the textile is the most productive one in China. This does not necessarily imply, though, that US's and China's comparative advantage in these industries is driven by industry specific factors. Following the common notion that US and China are well endowed in skilled and unskilled labour respectively, the optimal use of the national resources at the industry level indicate the real source of comparative advantage.

3.5.1 TFP Comparisons

The methodology used to construct TFP is very similar to approaches applied by Van Aark and Pilat (1993) and Harrigan (1999)), which build on the theory of index numbers by Caves et al. (1982). We assume that output is a value added function produced by the use of two inputs, labour and capital. For each industry i of country c at year t (industry and time subscripts are omitted for simplicity) the production function is written as:

$$y_c = f(l_c, k_c)$$

More specifically, we consider a production function with constant returns to scale as follows:

$$y_c = A_c l_c^\alpha k_c^{1-\alpha}$$

Parameter A embodies the concept of Total Factor Productivity (TFP) in a Solow residual fashion.

In a similar way, the production function of the reference country is determined as follows:

$$\bar{y} = \bar{A} \bar{l}^\alpha \bar{k}^{1-\alpha}$$

The logarithmic expression of the Relative TFP is given as:

$$\log RTFP_c = (\log y_c - \log \bar{y}) - \alpha(\log l_c - \log \bar{l}) - (1 - \alpha)(\log k_c - \log \bar{k}) \quad (3.9)$$

where $\log \bar{y}$, $\log \bar{l}$ and $\log \bar{k}$ are average values across observations in the sample. In the calculation of $RTFP_c$ index, α is measured by the average labour share $\alpha = (x_c + \bar{x})/2$, where x_c is the labour share of country c and \bar{x} is the average labour share of all observations in the sample. Imposing the assumption of constant returns to scale, then the capital share is equal to one minus the labour share. Initially, the labour share is computed as the ratio of labour compensation to value added. In many cases, this ratio is quite noisy exceeding unity. To control for these imperfections,

an approach proposed by Harrigan (1999) is followed by replacing labour share values greater than one with fitted values from the following OLS regression:

$$\log\left(\frac{w}{va}\right)_{i,c,t} = b_0 + b_1 \log\left(\frac{l}{k}\right)_{i,c,t} + \varepsilon_{i,c,t}$$

This regression is estimated for each industry, including a set of country and year dummies. Equation (3.9) is a special case of Harrigan's (1999) functional RTFP formula and it is directly derived from a translog production function. This index is transitive,⁵² making no difference which country is used as a means of comparison (i.e. in the present study, the reference point is an average over all observations in the sample).

The measurement of labour input in equation (3.9) is in physical units multiplying the number of employees by the number of average hours worked. However, value added, labour compensation and capital should be measured in a common currency value. The STAN database reports values for EMU countries in Euros (i.e. this excludes UK). Data are converted into a common currency, namely US Dollars, by using the purchasing power parity (PPP) exchange rate reported by the World Bank Development Indicators - International Comparison Project (ICP). Once the variables are converted into a common currency, the next step is to make the data comparable across years. To do so, value added, labour compensation and capital in (3.9) are expressed in 1995 constant prices using the associated variable deflators reported in the STAN database.

Admittedly, there are limitations in the conversion method used since the World Bank PPP-exchange rate is based on GDP prices, which are common across all sectors in the economy. This can be problematic potentially as output prices are likely to differ across sectors. GGDC (ICOP) develops an interesting methodology for the construction of PPP-exchange rates appropriate for international productivity comparisons at a disaggregate industry level.⁵³ Unfortunately, this data set

⁵² The property of transitivity implies that for any three countries c, c', c'' , the following equality is satisfied: $TFP_{cc'} = TFP_{c'c''} TFP_{cc''}$.

⁵³ Details regarding the construction of disaggregate PPP exchange rates can be found in Van Aark et al.(2002).

is only available for 1997. Hence, we have to cope with the aggregate PPP-exchange rate provided by the World Bank indicators.

The capital input used in (3.9) is a stock measure derived by a perpetual inventory method.⁵⁴ Gross capital flows from STAN include investments in fixed assets. The accumulation of capital stock in industry i is derived from the following equation:

$$K_{i,t} = (1 - \delta)K_{i,t-1} + Investment_{i,t-1}$$

where δ is a depreciation rate of capital assets, currently assumed to be at 10% and K_{t-1} is previous capital stock. The initial capital stock is obtained by the formula: $K_{0,i} = \frac{Investment_{0,i}}{g_i + \delta}$, where $Investment_{0,i}$ are purchases of capital in industry i on the first year available in the sample (i.e. 1987) and g is the average growth rate of capital purchases over the whole period.⁵⁵

Productivity is a strictly procyclical variable and thus dependent on business cycle movements. OECD (Main Economic Indicators) reports data on a quarterly basis for the degree of capacity utilisation in the aggregate manufacturing sector. The cyclicity of RTFP is captured by multiplying capital stock with the share of capacity utilisation. This indicates that the effect of the business cycle matters only for cross-country comparisons and not for comparisons across industries in the same country.⁵⁶

Table B3.4 in Appendix B displays average RTFP from equation (3.9) over the period 1987-2002 considering Germany as the base of comparison. Germany is more productive than most of the countries in almost all manufacturing industries followed closely by France, which exceeds German's RTFP in some cases. UK manages to close the productivity gap with Germany only in

⁵⁴ STAN already reports data on capital stock by aggregating past and current capital assets. These measures are not adjusted for the expected physical depreciation; the Perpetual Inventory Method (PIM) followed represents a more accurate measure of capital stock.

⁵⁵ The reader is referred to Chapter 2 of the thesis for a more detailed discussion regarding the measurement problems involved in the calculation of the initial capital stock.

⁵⁶ Given that the current study focuses on cross-country TFP comparisons at the industry level, the fact that the utilisation index is aggregate does not prevent us from measuring the effect of business cycle across years. However, it should be noted that movements over the business cycle are likely to have different cross-industry effects within the same country since the effect of utilisation is strongly determined by the capital-labour ratio of the individual industry.

the food industry while in the remaining industries the RTFP gap between the two countries remains quite large. A similar pattern applies for Italy and Spain; exceptionally the latter countries maintain a productivity advantage compared to Germany only in Coke and petroleum industry. Turning to Greece-Germany RTFP comparisons, the numbers are quite discouraging for the productivity records of Greek industries. Greece's productivity is less than half of Germany's in all industries, with exception the coke industry (60%), where Greece manages to narrow the productivity gap.

3.5.2 Factor Endowments and Industry Factor Intensity

As already discussed, a core issue which requires systematic treatment in a joint model is to identify the potential sources of productivity differences across countries. An extensive investigation of the sources of productivity differences across countries is a topic of research itself and certainly, it cannot be fully addressed in the present study. However, the present sub-section investigates whether forces proposed by H-O (i.e. factor endowments) are associated with forces proposed by the Ricardian theory. To implement this investigation, we specify a channel via which factor abundance is linked to an industry's productivity.

The theoretical model in section (3.2) does not clearly state whether factor price equalisation (FPE) holds.⁵⁷ It is implicitly assumed that FPE holds and thus there is no need to examine what happens to the pattern of specialisation when factor prices differ across countries.⁵⁸ Davis and Weinstein (2001a) mention that FPE fails even among developed countries indicating that when factor rewards vary across countries, this has an effect on the type of goods that each country produces. Under the standard assumptions of perfect competition, free trade, zero transportation costs⁵⁹ and no qualitative differences in the factors of production, the only plausible explanation for

⁵⁷ Harrigan (1997) attributes the existence of FPE to the fact that the dual translog revenue function is valid at all points in the sample.

⁵⁸ Interpreting this assumption in the terminology of trade theory, the fact that FPE holds implies that countries operate in a one cone-model. See for further details Harrigan (2001).

⁵⁹ Romalis (2004) shows that the transportation costs can directly lead to FPE failure.

the failure of FPE is in the differences of relative factor endowments.⁶⁰ An important implication of FPE failure is that national factor endowments can directly drive the choice of production inputs at the industry level. Schott (2003) formally represents that if countries experience high rates of capital accumulation then relative factor rewards are also affected. This will lead capital abundant countries to be systematically biased towards capital inputs in all sectors. Linking this statement with Romer's (1990) proposition that capital accumulation is a main source of technical progress then the resulting puzzle suggests that national capital abundance has an indirect positive influence on productivity at the industry level. Similarly, Acemoglu (2002) illustrates that if countries are well endowed in skilled labour then their TFP is systematically higher in all industries.

The methodology that we apply does not directly prove whether sectoral productivity is a function of factor endowments. Instead, we use equation (3.10) to test the hypothesis of whether national factor endowments determine industry factor intensity:⁶¹

$$\left(\frac{k}{l}\right)_{i,c,t} = \mu_0 + \mu_1 \left(\frac{K}{L}\right)_{c,t} + \nu_c + \eta_t + u_{i,c,t} \quad (3.10)$$

where the left hand side of the regression represents the capital–labour ratio in industry i of country c at year t . The right-hand side of (3.10) includes the aggregate capital-labour ratio of the country plus a group of country and year fixed effects. Model (3.10) is estimated by OLS after pooling observations across countries and years. Equation (3.10) is not derived from a well-specified structural model but its economic interpretation is clear and intuitive. If the estimated coefficient μ_1 is significantly different from zero then, there is evidence that national factor abundance is associated with industry factor intensity. In other words, national factor supplies drive the choice of input mixes at the disaggregate level. In case that the estimated μ_1 is zero, then aggregate factor supplies are uncorrelated with factor intensity at the industry level and hence one

⁶⁰ Certainly, this set of assumptions should include that productivity of factors are the same across countries. For the purposes of the current analysis, productivity is modelled as industry specific and thus national factors are not adjusted in productivity units.

⁶¹ This regression was suggested by Harrigan (2001) indexed as equation (25).

has obtained a signal that the H-O propositions do not bias the Ricardian forces in the determination of the sources of specialisation.⁶²

Table 3.6 OLS Estimates from Equation (3.10)-National Factor Endowments as Determinants of Industry Factor Intensity

Industry	K/L	N	R-squared
Food Products	0.192 (1.79)	75	0.81
Textiles	0.008 (0.11)	75	0.89
Wood	-0.264 (0.82)	60	0.8
Pulp and Paper	-0.158 (1.06)	75	0.66
Coke	-0.174 (0.95)	75	0.81
Chemicals	-0.055 (0.42)	75	0.67
Plastics	-0.103 (0.93)	75	0.65
Other non-metallic	0.273 (1.33)	75	0.85
Basic Metals	0.229 (1.21)	75	0.78
Machinery	-0.131 (1.67)	75	0.69
Electrical	-0.076 (0.54)	75	0.58
Transport	-0.012 (0.10)	75	0.67
Other-Manufacturing	-0.053 (0.44)	75	0.86

Notes:

The dependent variable is the capital labour ratio at the industry level and the column reports estimates for the coefficient of the aggregate capital-labour ratio. Parentheses report t-statistics from OLS estimation with robust standard errors clustered by country

Results from Table (3.6) clearly suggest that national endowments are not correlated with industry factor intensity. The insignificant estimated coefficients indicate that there is no sensitivity between a change in the aggregate relative factor supply and the use of this factor at the industry level. Intuitively, countries that are more capital abundant are not necessarily biased towards

⁶² Equation (3.10) is also an empirical test for the Factor Price Insensitivity (FPI) effect. A statistically positive coefficient of μ implies that changes in relative factor endowments have an effect in factor prices. On this basis, increases in the national capital-labour ratio means that the price of capital services is relatively cheaper and thus individual industries find economic efficient to substitute labour with capital inputs.

capital-intensive techniques and thus national factor endowments cannot drive productivity at the industry level. This evidence differs from findings of previous studies (Davis and Weinstein (2001b)), which estimate a similar equation to (3.10). Furthermore, the lack of significant evidence between aggregate factor endowments and industry factor intensity is an indirect signal that FPE holds across countries of the present sample. More precisely, there maybe factor price differences across countries but they are too small to drive the pattern of specialisation. This is a reasonable hypothesis considering that the sample includes only European countries with a similar level of development. In the present context, the lack of correlation between national factor endowments and industry factor intensity is undoubtedly a convenient outcome for the following steps of the empirical exercise.⁶³ Nonetheless, researchers should be very careful when they try to draw generalised statements about the existence of FPE, as Davis and Weinstein suggest (2001a, Figure 1) wage differentials can be large even within a group of OECD countries. This issue should be always under investigation as the validity of FPE theorem depends strongly on the data set under study.

3.5.3 Estimating the Joint Model of Specialisation

The next step is the estimation of a joint model that includes both productivity and relative factor endowments as determinants of specialisation. The structural form of the model is based on equation (3.6) in the previous section. The parameter θ is the RTFP of equation (3.9). The estimable equation takes the following form:

$$s_{i,c,t} = \beta_{0i} + \beta_1 RTFP_{i,c,t} + \beta_2 \log\left(\frac{K}{L}\right)_{c,t} + \beta_3 \log\left(\frac{SL}{L}\right)_{c,t} + \beta_4 \log\left(\frac{A}{L}\right)_{c,t} + \beta_5 \log\left(\frac{E}{L}\right)_{c,t} + u_{i,c,t} \quad (3.11)$$

⁶³ Morrow (2006) provides a formal proof for whether H-O and Ricardian forces are interrelated by conducting a direct correlation test between industry factor intensity and TFP. The conclusions emerged from Morrow (2006) are in the same line with the results provided in this section confirming the independence between the H-O and the Ricardian effects on specialisation.

The only difference between specifications (3.7) and (3.11) is that RTFP is now included as a determinant of specialisation. Specification (3.11) is estimated for each industry with SUR with the inclusion of country and year fixed effects.

Table 3.7 SUR Estimates of Equation (3.11)-Industry Output Shares as a Function of RTFP and National Factor Endowments

Industry	RTFP	K/L	SL/L	A/L	E/L	L.H.R chi2 (1)	N	R- squared
Food	0.10*** (3.68)	0.12 (0.96)	-0.41*** (3.71)	0.12 (1.39)	0.17** (2.23)	0.72	55	0.8
Textiles	0.05*** (3.06)	-0.046 (-0.36)	-0.27** (2.39)	-0.043 (0.47)	0.041 (0.53)	0.17	55	0.71
Wood	0.031 (1.26)	-0.152 (1.37)	-0.048 (0.48)	0.14* (1.89)	-0.36*** (5.43)	0.00	55	0.96
Pulp and Paper	0.06*** (3.68)	0.007 (0.047)	-0.37*** (2.63)	-0.11 (0.99)	-0.19** (1.96)	0.18	55	0.77
Coke and Petroleum	0.19*** (5.77)	1.05*** (3.73)	-1.37*** (5.44)	0.25 (1.22)	0.33* (1.90)	0.00	55	0.84
Chemicals	0.08*** (3.68)	0.77*** (3.76)	-0.79*** (4.32)	0.27* (1.86)	0.48*** (3.84)	0.40	55	0.87
Plastics	0.06** (2.21)	0.254 (0.97)	-1.45*** (6.23)	0.85*** (4.51)	0.46*** (2.95)	0.206	55	0.75
Other non- metallic	-0.019 (0.91)	0.53*** (5.83)	0.77*** (9.16)	-0.019 (0.30)	0.10* (1.92)	0.323	55	0.91
Basic Metals	-0.043*** (3.30)	-0.36*** (3.69)	0.09 (1.10)	-0.014 (0.21)	-0.084 (1.41)	0.00	55	0.91
Machinery	-0.01** (2.43)	-0.64** (2.07)	2.04*** (7.39)	-1.37*** (6.10)	-1.06*** (5.69)	0.48	55	0.89
Electrical	0.00 (0.33)	0.51*** (3.35)	-0.19 (1.46)	0.34*** (3.10)	-0.00 (0.090)	0.00	55	0.86
Transport	-0.021** (1.99)	-0.47*** (6.39)	0.008 (0.13)	-0.36*** (6.65)	-0.039 (0.88)	0.15	55	0.96
Other Manufacturing	-0.086 (1.01)	-1.73*** (3.45)	1.51*** (3.55)	-1.24*** (3.50)	-1.04*** (3.57)	0.00	55	0.63
S.R chi2(12)		191.98 (0.00)	481.47 (0.00)	289.97 (0.00)	446.39 (0.00)			

Notes:

Coefficients are standardised beta coefficients with absolute t-statistics in parentheses; The asterisks correspondence is *significance at 10%; **significance at 5%; ***significance at 1%. Each equation includes a set of country and year dummies (estimates are not shown for brevity). The linear homogeneity

(L.H) and symmetry (S) restrictions refer to the tests: $\sum_j \beta_{2j,m} = 0$ and $\beta_{m,j} = \beta_{j,m}, \forall i \neq k$ (see section 3.2

for further discussion). For the (L.H) restriction the p-values reported derived from the test whether the sum of the factor endowments estimates in each equation is zero The Wald statistic used follows the Chi-squared distribution with degrees of freedom equals to the number of restrictions. To test for the homogeneity restriction for all thirteen industries, the Wald statistic is Chi(13)=236, p-value=0.00. The symmetry (S) restriction refers to the test whether factor endowments have the same effect across equations. Since we do not use the cross RTFP effects in the estimation we do not test the hypothesis

$$\beta_{i,k} = \beta_{k,i}$$

Table (3.7) is organised in the same way as Table (3.3). Each row corresponds to an industry and each column lists the estimates for the determinants of specialisation. The third column from the end shows p-values after testing for the linear homogeneity assumption imposed in equation (3.6), which is the theoretical device of the empirical specification. The last row tests the restriction whether the effect of a particular factor endowment is the same across industries. Wald test is the appropriate statistic for testing these restrictions so the Chi-square values are reported.

The first column refers to the effect of RTFP across industries. Notice that RTFP is own-TFP expressed relative to a reference point, which is the average of the whole sample. The RTFP estimate is positively signed in 8 out of 13 industries while in seven of them the coefficient is significant at high statistical levels. RTFP is a significantly positive determinant of specialisation mainly in the so-called low and medium technology industries while in some of the traditionally high-technology industries the estimated coefficient has a negative sign. Given that all variables in (3.11) are expressed in logarithms, it allows us to give a more direct interpretation of the coefficients. For example, one percent increase in RTFP in, say textiles, leads to a 5.2 percent increase in the industry's output share to GDP. The strongest RTFP effect is found in coke industry, in which one percent increase in RTFP raises output share by 19.6 percent.

Surprisingly, the estimated RTFP coefficient in basic metal and transport industries has a negative sign in. This contradiction of our theoretical priors might be due to various unobserved forces or could simply reflect government intervention in these industries. Natural-based industries such as basic metals are highly regulated in almost all countries of the sample. Similarly, transport industry has an infant and supporting role in the economy implying the importance of government subsidies for the operation of those industries. This type of policy eliminates substantially the incentives for improving efficiency standards but ensures a high industry share in national GDP.

Turning to the estimated effect of relative factor endowments, the relative capital labour abundance, (K/L) , remains an important source of specialisation but only in industries that use this factor intensively. The first remark about capital-labour ratio is that the estimated coefficient is now

significant in a smaller number of industries compared to Table (3.3) (i.e. four out of thirteen). However, there is a perfect match between industries with a positive estimate of capital abundance and their associated factor intensity in Table (3.5). In the latter table, industries of coke, electrical and chemicals are the most capital intensive of the sample and the estimated coefficient of (K/L) in these industries is positive and statistically significant. To understand better the economic significance of the above estimates, the standardised beta coefficients are reported. Beta coefficients indicate the expected change in standard deviation of the dependent variable after a one standard deviation change in the independent variable (Leamer (1984)). According to this interpretation, the most significant effect of capital abundance is documented on the coke industry in which a one standard deviation increase in capital abundance increases output share by 1.05 standard deviations. Conversely, the strongest negative effect is found in other manufacturing in which a one standard deviation increase of capital abundance decreases industry's output share by 1.73 standard deviations.

For skilled labour abundance (SL/L) it is difficult to recognize to what degree the estimates produced are consistent with the actual factor intensity because there is no information for skilled labour intensity at the industry level for all countries. However, the pattern emerged from Table (3.7) provides a powerful inference: skilled labour abundance is not a source of comparative advantage in manufacturing industries. In six out of the thirteen industries, the estimated coefficient of skilled labour ratio is negative and statistically significant while only in three industries, the skill abundance has a positive and significant effect on industry's share to country's GDP. These findings confirm a general tendency documented also in other empirical studies (Leamer (1984), Harrigan (1995), Redding (2002) and Reeve (2006)). The most prominent story hidden behind this negative effect implies that the nature of manufacturing jobs do not generally require highly educated workers, thus when labour inputs are driven from other sectors of the economy to manufacturing, this comprises losses of competitiveness for manufacturing industries (Harrigan (2001)).

It is difficult to identify a clear relationship between land abundance (A/L) and comparative advantage. In contrast to common beliefs, abundance of arable land is of minor importance in the food industry, while in the other natural resource oriented industry, wood, a positive effect is present. In high-technology industries of machinery and transport equipment, land abundance is clearly a source of disadvantage; however, the coefficient of arable land is unusually positive and significant in electrical industry.

Finally, the last column of table five presents the effects of energy abundance (E/L) on the pattern of specialisation. Considering the energy intensity at the industry level (Table (3.5)), the ranking indicates that coke, chemicals, rubber and plastics and other non-metallic industries are relatively the most intensive industries in the use of energy. Energy abundance carries a positive coefficient in these four industries. On the contrary, industries ranked as less energy intensive have a negative coefficient. A striking result emerged from Table (3.7) is that in the industries of transport and basic metals, we cannot identify any significantly positive determinant of specialisation. The current availability of production inputs at the industry level does not allow us to investigate what type of factors used intensively in these industries. Although, one might expect that capital abundance should have been a positive determinant of output share at least in the transport industry, which uses quite intensively that factor (see Table (3.5)). Apart from this inconclusive point, the overall evidence from Table (3.7) clearly indicates that the H-O mechanisms are evident in the present sample.

Regarding the test of the homogeneity restriction, the chi-squared values clearly suggest that the hypothesis that $RTFP$ and factor endowments coefficients are jointly zero is rejected at high statistical levels. The intuitive interpretation of this outcome advocates that a joint specification performs well, an argument that can be also supported by the high R-squared values. Especially, the latter statistic signifies that both H-O and Ricardian forces explain much of the variation of industry's output share. The test of symmetry restrictions presented in the last row rejects the null at high statistical levels indicating that the impact of factor endowments differ across industries. This

result accords with the main priors of the Rybczynski theorem highlighting that the impact of national factors supplies across industries depends on how intensively industries use these factors.

3.6 Sensitivity Analysis-Further Specifications

Another important issue involved in estimating (3.11) is to what degree unobservable and chronic errors in the measurement of the variables used can give biased estimates. For national factor supplies, a central issue is whether quality differences that are excluded from the current definitions are sources of serious bias in the econometric results. For instance, current definitions do not take into account climate conditions in the measure of land or differences in the years of schooling in the measure of labour. A common attribute of the above effects is that most (if not all) of them are fixed across time and to some extent their impact on the pattern of specialisation can be effectively captured via country fixed effects.⁶⁴ Another issue is that the PPP-exchange rate is based on prices of aggregate output instead of prices of a more disaggregate level. O' Mahoney (1996) notes that the relative TFP measures can vary substantially according to the PPP-exchange rate used for conversion implying that researchers should always bare in mind that TFP indices are subject to measurement errors. The ideal solution to any measurement problem is the use of an instrumental variable approach. Valid instruments for factor supplies are almost impossible to find. However, recognising the positive role of research and development (R&D) on promoting TFP, the one year lagged of R&D share is used as instrument for the RTFP variable. Moreover, if one considers that technology is mobile across industries within a country then it can be used as instrument of RTFP in industry i the average RTFP of all other industries in country c .⁶⁵ The set of instruments is defined as:

⁶⁴ Klepper and Leamer (1984) suggest that classical errors in the measurement of factor endowments are bounded and can be viewed as a function of regression's R^2 . In the current estimations, R^2 is high in all industries indicating that any problem might occur from measurement errors is small.

⁶⁵ For these instruments to be valid, a further assumption is needed that while RTFP across industries are correlated, RTFP errors are not. A similar argument is used by Harrigan (1997), but in his case as instruments of TFP in industry i is used the average TFP of this industry across all countries in the sample.

$$\frac{1}{I-1} \sum_{k \neq i}^{I-1} RTFP_{k,c,t} \quad ,$$

where I is the number of industries in country c .

Table 3.8 2SLS Estimates of Equation (3.11)-Industry Output Shares as a Function of RTFP and National Factor Endowments

Industry	RTFP	K/L	SL/L	A/L	E/L	L.H.R chi2 (1)	N	Adj. R-squared
Food	0.108 (1.52)	0.117 (0.72)	-0.411*** (2.87)	0.123 (1.08)	0.169* (1.73)	0.17	55	0.80
Textiles	0.114*** (2.90)	-0.174 (0.98)	-0.198 (1.33)	-0.126 (1.01)	-0.009 (0.084)	0.45	55	0.73
Wood	0.0715* (1.85)	-0.200 (1.40)	0.000 (0.002)	0.120 (1.19)	-0.381*** (4.47)	0.02	55	0.96
Pulp and Paper	0.103** (2.04)	-0.036 (0.17)	-0.346* (1.90)	-0.132 (0.90)	-0.204 (1.64)	0.16	55	0.78
Coke and Petroleum	0.293** (2.38)	1.027*** (2.84)	-1.392*** (4.31)	0.178 (0.64)	0.345 (1.55)	0.35	55	0.84
Chemicals	0.293** (2.38)	0.630** (2.31)	-0.693*** (2.89)	0.192 (0.99)	0.436*** (2.70)	0.46	55	0.88
Rubber	0.148** (2.38)	0.078 (0.23)	-1.310*** (4.26)	0.713*** (2.79)	0.399* (1.94)	0.18	55	0.76
Other non-metallic	0.007 (0.22)	0.518*** (4.44)	0.808*** (7.38)	-0.029 (0.34)	0.103 (1.44)	0.65	55	0.91
Basic Metals	-0.0637** (2.54)	-0.342*** (2.68)	0.067 (0.57)	-0.001 (0.008)	-0.078 (1.01)	0.37	55	0.91
Machinery	-0.141** (2.33)	-0.530 (1.30)	1.958*** (5.46)	-1.29*** (4.40)	-1.023*** (4.25)	0.48	55	0.89
Electrical	0.033 (1.09)	0.466** (2.35)	-0.165 (0.94)	0.311** (2.20)	-0.027 (0.23)	0.39	55	0.87
Transport	-0.024 (1.64)	-0.474*** (4.97)	0.005 (0.053)	-0.357*** (5.17)	-0.038 (0.66)	0.15	55	0.96
Other Manufacturing	-0.281** (2.14)	-1.278* (1.92)	1.278** (2.33)	-0.957** (2.06)	-0.873** (2.30)	0.08	55	0.65
S.R chi2(12)		6.51 (0.00)	12.45 (0.00)	5.43 (0.00)	5.37 (0.00)			

Notes:

Coefficients are standardised beta coefficients with absolute *t*-statistics in parentheses; The asterisks correspondence is *significance at 10%;** significance at 5%;***significance at 1%. The estimation applied is 2SLS using as instruments for RTFP an one year lagged R&D share, average RTFP of all industries in the country and a set of country and year dummies. Estimates from the endogenous equation are not reported to save space. The linear homogeneity (**L.H**) and symmetry (**S**) restrictions refer to the tests:

$\sum_j \beta_{2j,m} = 0$ and $\beta_{m,j} = \beta_{j,m}, \forall i \neq k$ (see section 3.2 for further discussion). For the (**L.H**) restriction the p-values reported derived from the test whether the sum of the factor endowments estimates in each equation is zero The Wald statistic used follows the Chi-squared distribution with degrees of freedom equals to the number of restrictions. To test for the homogeneity restriction for all thirteen industries, the Wald statistic is Chi(13)=236, p-value=0.00. The symmetry (**S**) restriction refers to the test whether factor endowments have the same effect across equations. Since we do not use the cross RTFP effects in the estimation we do not test the hypothesis $\beta_{i,k} = \beta_{k,i}$

Table (3.8) shows the results from the 2SLS estimation and the use of instrumental variables for RTFP. Tables (3.8) and (3.5) show similar results. Some differences occur in the significance of the estimates of all variables but the economic intuition of the results remains the same. RTFP is positive and significant in six of the thirteen industries while RTFP has a negative and significant coefficient in three industries. The estimated coefficient of capital and skilled labour abundance remains unchanged, while the effect of arable land is now significantly positive only in the rubber industry. Small differences are also revealed regarding the impact of energy abundance using a 2SLS estimation. The coefficient of this factor is not significant any more in the industries of coke and other non-metallic. Testing for homogeneity and symmetry restrictions provides the same results as in Table (3.7).

A further check of robustness for the results presented in Table (3.7) is to control for the speed of adjustment in the output share after a change in productivity and relative factor supplies. An underlying assumption of the neoclassical model is that there is free movement of the factors of production across industries within the same country. In a more realistic setting, the implementation of this reallocation takes time. This implies that an increase (or decrease) in industry i 's RTFP needs a certain period to reflect an increase (or decrease) in industry i 's output share. A similar effect is at work for changes in relative factor endowments. A possible way to allow for time adjustment in the model is to estimate (3.11) by taking all the right-hand side variables in one year lags. Harrigan (1997) allows for slow adjustment and persistence in industrial structure by adding a dependent variable in the right-hand side of the empirical specification. In the current model, this dynamic specification is rather problematical since the time span of the panel is relatively short and an OLS estimation of (3.11) is likely to give a downward biased estimate for the coefficient of the lagged dependent variable (Hsiao (1986)). Due to this inconsistency, slow adjustment in the model is accounted for by lagging all the right-hand side variables.

Table 3.9 SUR Estimates of Equation (3.11)-Industry Output Shares as a Function of Lagged RTFP and National Factor Endowments

Industry	L1.RTFP	L1.K/L	L1.SL/L	L1.A/L	L1.E/L	L.H.R chi2 (1)	N	Adj. R- squared
Food	0.0813*** (2.82)	0.085 (0.66)	-0.403*** (3.55)	0.094 (1.05)	0.140* (1.79)	0.16	51	0.790
Textiles	0.0447** (2.42)	0.044 (0.32)	-0.302*** (2.58)	0.028 (0.29)	0.093 (1.14)	0.11	51	0.720
Wood	0.034 (1.59)	-0.171 (1.49)	0.031 (0.30)	0.117 (1.46)	-0.380*** (5.48)	0.12	51	0.960
Pulp and Paper	0.0572*** (3.19)	0.091 (0.53)	-0.363** (2.39)	-0.069 (0.57)	-0.149 (1.42)	0.13	51	0.760
Coke and Petroleum	0.219*** (5.35)	1.054*** (3.36)	-1.351*** (4.86)	0.232 (1.04)	0.339* (1.76)	0.27	51	0.830
Chemicals	0.0656*** (2.82)	0.810*** (3.68)	-0.777*** (4.01)	0.277* (1.79)	0.497*** (3.70)	0.36	51	0.880
Rubber	0.0554** (2.21)	0.619** (2.38)	-1.520*** (6.65)	1.111*** (6.00)	0.689*** (4.36)	0.17	51	0.790
Other non- metallic	-0.004 (0.19)	0.325*** (3.19)	0.865*** (9.26)	-0.168** (2.33)	0.002 (0.035)	0.44	51	0.900
Basic Metals	-0.0272** (2.04)	-0.427*** (3.72)	0.068 (0.66)	-0.041 (0.51)	-0.128* (1.82)	0.23	51	0.890
Machinery	-0.103*** (2.83)	-0.831** (2.41)	2.020*** (6.73)	-1.469*** (6.02)	-1.189*** (5.74)	0.37	51	0.890
Electrical	0.002 (0.093)	0.752*** (4.66)	-0.129 (0.92)	0.446*** (3.94)	0.126 (1.29)	0.34	51	0.880
Transport	-0.009 (0.76)	-0.597*** (6.74)	-0.037 (0.47)	-0.408*** (6.49)	-0.111** (2.08)	0.01	51	0.950
Other Manufacturing	-0.197** (2.24)	-1.523*** (2.78)	1.036** (2.30)	-0.998*** (2.64)	-1.035*** (3.24)	0.65	51	0.660
S.R chi2(12)		178.46 (0.00)	442.88 (0.00)	311.19 (0.00)	451.51 (0.00)			

Notes:

Coefficients are standardised beta coefficients with absolute t -statistics in parentheses; The asterisks correspondence is *significance at 10%; ** significance at 5%; ***significance at 1%. Observations are weighted by the inverse of GDP to account for group-wise heteroscedasticity. All variables are lagged by one year to allow for slow adjustment. The linear homogeneity (**L.H**) and symmetry (**S**) restrictions refer

to the tests: $\sum_j \beta_{2j,m} = 0$ and $\beta_{m,j} = \beta_{j,m}, \forall i \neq k$ (see section 3.2 for further discussion). For the (**L.H**)

restriction the p-values reported derived from the test whether the sum of the factor endowments estimates in each equation is zero The Wald statistic used follows the Chi-squared distribution with degrees of freedom equals to the number of restrictions. To test for the homogeneity restriction for all thirteen industries, the Wald statistic is Chi(13)=236, p-value=0.00. The symmetry (**S**) restriction refers to the test whether factor endowments have the same effect across equations. Since we do not use the cross *RTFP* effects in the estimation we do not test the hypothesis $\beta_{i,k} = \beta_{k,i}$

Table (3.9) reveals that there are no remarkable differences even after allowing for time adjustment in productivity and factor supplies. The effects of RTFP, capital and skilled labour endowments are almost identical to that depicted in Table (3.7). The coefficient of arable land in wood industry becomes now insignificant while the effect of arable land in the electrical industry

preserves a peculiar positive coefficient. No notable differences occur regarding the abundance of energy, which maintains the same sign across industries as in previous specifications with some minor changes in the t -values of the estimated coefficients. Results from Table (3.9) provide an additional confirmation that controlling for lag in output share responses after changes in RTFP and factor endowments does not cause remarkable differences in the estimates.

3.7 Discussion-Conclusions

This chapter contributes to the existing literature in a number of different aspects. The main goal of the chapter is to analyse the determinants of industrial structure in six EU countries. This empirical exercise is implemented within the key propositions of the H-O theorem of trade. On that basis, the main contribution of the chapter is that the evidence emerged allows us to assess the validity of the neoclassical trade model. The theoretical device used for this task is an articulated model that jointly estimates the contribution of H-O and Ricardian forces to the pattern of specialisation.

The identification of the determinants of industrial specialisation is equivalent to investigating the sources of comparative advantage across industries. There is not a single study that can provide definite answers to such complicated and crucial issue. The present study points out some new directions in how researchers should investigate the sources of comparative advantage and specialisation. This new direction suggests that one can understand better the sources of specialisation only if he takes into account that industrial structures is affected jointly from general and partial equilibrium forces. The gain from this consideration is that the economic policy designed can be more effective.

A significant amount of studies applies partial equilibrium approaches to identify the determinants of industrial structure. The underlying argument of these approaches is that specialisation is exclusively governed by industry specific characteristics. However, this scenario is incomplete since it systematically excludes the general equilibrium effects on individual industries.

The present study analyses the pattern of specialisation within a general equilibrium framework including factors that both reflect national endowments and industry individual performance. The H-O and Ricardian models formally represent these separate factors. A joint model provides useful guidance for the contribution of each model to the pattern of specialisation, assisting vitally to the design of an appropriate policy. To influence the pattern of specialisation towards specific production activities, horizontal policies that encourage the adoption of technological and managerial advances are not enough if they are not accompanied with the accumulation of the right factors.

The empirical estimation of the model is implemented in two stages. The first stage refers to a model that excludes productivity as a source of specialisation. This specification corresponds to a static Rybczynski-type effect, which is the equilibrium representation of the H-O theory. An interesting extension of the Rybczynski equation is also implemented for the case of Greek bilateral trade. Estimated coefficients from both the production and the trade version of the model correspond to the actual industry factor intensities indicating that the H-O model performs quite well.

The estimation of a joint model enhances some distinguishable complications that need special treatment in order to make the implementation of the model meaningful. Although, it is used a dual approach, which implicitly ensures that the translog revenue approximation is valid at all points, there is a key issue regarding the presence of FPE. Non-existence of FPE is likely to cause correlation between national factor abundance and disaggregate productivity. Due to the nature of the countries currently in the sample, the assumption of FPE is not violated allowing us to proceed with a joint estimation. Results from this estimation reveal that both factor endowments and productivity matter in the determination of the comparative advantage.

Undoubtedly, there are still many unexplored issues in order to say that we understand perfectly the pattern of specialisation. The current analysis offers support for the empirical validity of a joint model but the specifications used throughout the chapter face some limitations. One of

them is the lack of a well-specified alternative scenario for the pattern of specialisation. Many studies that seek to assess the validity of the international trade theories encounter this standard problem (Harrigan (2001)). Harrigan and Zakrajšek (2000) and Fitzgerald and Hallak (2004) consider as alternative hypothesis that movements in country overall productivity can increase industry output. This alternative view can be easily accommodated in the present analysis constituting an interesting extension to the present specifications.

The specifications estimated in the chapter represent mainly static effects of specialisation providing no information for how comparative advantage changes endogenously over time. Helpman (1998) mentions that the global economy changes radically calling for new developments in international trade theory that will provide us with insights about the dynamic changes in the nature of comparative advantage. Endogenous growth theory suggests that a country's comparative advantage is likely to be determined by accumulation of knowledge or trade. According to these effects, the pattern of specialisation preserves persistency and it is subject to international knowledge spillovers. Redding and Proudman (2000) and Redding (2002) investigate the dynamics of specialisation addressing systematically some of the above effects. The investigation of the dynamics of specialisation can offer plausible answers regarding changes in the pattern of production over time. For instance, if an industry has a persistently small output share, what is the probability for this industry to remain as such after a given period? Certainly, these issues constitute interesting paths for future research.

Differences in technology in the Ricardian model are viewed as exogenous. This simplistic assumption is not adopted any more and an intensive research is carried out to investigate the sources of international productivity differences. The present analysis restricts this investigation to analysing the extent to which factor endowments dictate the mix of inputs at the micro level; however, it does not explain, for example, why Germany is more productive in the transport industry than Spain. By drawing clear conclusions for which factors have a clear impact on

productivity differentials across countries, the mechanisms driving the puzzle of international specialisation will be more visible. Parts of these issues are examined in chapter 4 of the thesis.

Appendix B

Appendix B3.1

Data for Factor Supplies are taken from World Bank Development Indicators. The former source provides country level data for shares of labour force based on the educational level, energy production in oil equivalent, purchases of fixed capital assets and hectares of arable land. Many countries do not conduct labour surveys on an annual base and thus many missing values are reported in labour data. Missing values are filled using a linear interpolation procedure. Assuming that changes in educational level of labour force is a linear function of time then missing numbers within a time interval are filled with the mean value of non-missing numbers, Stata 8 Manual (2003) provides further details for the interpolation procedure. Flow data on fixed capital assets and inventories are reported in US dollars but the measure used in the empirical analysis is capital stock calculated via a standard Perpetual Inventory Method (PIM). The PIM is used to compute capital stock both for industries and countries level. For issues related to the computation of capital stock see section 2.4.2 in Chapter 2.

The OECD-STAN is the main provider of industry level data but some additional information is also taken from the Groningen Growth and Development Centre (GGDC). STAN provides industry level data in ISIC Rev.3 classification for the following variables: value added, value added deflator, labour compensation of employees, number of employees, gross fixed capital formation and capital deflator. for The R&D data used to instrumentalise RTFP variable are obtained from OECD-R&D Expenditure Database, exceptionally R&D data for Greece are taken from OECD –Total Intramural Expenditure (13r3). R&D figures are reported in PPP-USD. The STAN database reports missing values for capital and value added deflators. In order to avoid dropping observations with missing values, missing numbers are filled by information taken from GGDC (60-Industry database) and GGDC (KLEMS). Data for hours worked per employee, intermediate energy inputs and their associated index deflators are taken by GGDC (60-Industry database) and GGDC (KLEMS), respectively. Notice that German industry data for years prior to 1991 refer only to Western Germany. Data for capital and the

number of employees in Greek industries starts from 1995, so data for prior years are taken exclusively from GGDC (KLEMS). Initially all data are reported in national currency (i.e. Euro for Euro-zone countries and GBP for UK), these are converted to USD using PPP-exchange rates (see also the text). The table below summarises the variables used in the study and their data sources.

Table B3.2 Summary of Data Sources

Period	1987-2003 (Industry data series finishes in 2002)	
Countries	France, Germany, Greece, Italy, Spain, UK	
Trade flows	Bilateral Trade Data Base	OECD-STAN
Industries- ISIC (Rev.3)	Food Products, Beverages and tobacco Textiles, Textile Products, Leather and Footwear Wood and Products of Wood and Cork Pulp, Paper, Paper Products, Printing and Publishing Coke, Refined Petroleum Products and Nuclear Fuel Chemicals and Chemical Products Rubber and Plastics Products Other Non-Metallic Mineral Products Basic Metals and Fabricated Metal Products Machinery and Equipment, nec Electrical and Optical Equipment Transport Equipment Manufacturing nec	OECD-STAN and GGDC (60-Industry Database and KLEMS)
Industry- Variables	Value Added, Labour Compensation, Number of Employees, Gross Fixed Capital Formation, Intermediate Energy Inputs, Hours Worked, R&D Expenditure, Capacity utilisation (Values are expressed in USD)	
Factor Supplies <u>Land</u> : hectares of arable land, km ² of forest land is also used <u>Energy</u> : production of energy converted into KG of oil equivalent <u>Capital</u> : stock measures calculated via an inventory method from investments in fixed capital fixed assets <u>Labour</u> classified by educational level:	World Bank Development Indicators World Bank Development Indicators World Bank Development Indicators	
<ul style="list-style-type: none"> Low Skilled-Labour Share with primary education Medium-Labour Share with secondary education High-Labour Share with tertiary education 	<ul style="list-style-type: none"> Less-Skilled labour: Labour Share with primary and secondary education Skilled labour: Labour Share with tertiary education 	World Bank Development Indicators adjusted the from International Labour Organisation (ILO)
PPP- Exchange Rate	National Currency to USD	World Bank Development Indicators –ICP Project

Table B3.3 Shares of Greek Trade with Five EU Countries

Partner	Import Share Compared to EU-15	Export Share to EU-15	Import Share Compared to Total World	Export Share to Total World
France	0.117	0.103	0.081	0.058
Germany	0.261	0.344	0.181	0.193
Italy	0.232	0.215	0.161	0.119
Spain	0.049	0.045	0.033	0.023
United Kingdom	0.088	0.135	0.061	0.072
Total	0.75	0.84	0.52	0.47

Table B3.4 Average RTFP for 1987-2002 (Germany=100)

Industry	France	Greece	Italy	Spain	UK	Germany
Food	116.8	31.9	96.8	70.1	77.0	100
Textiles	103.4	21.7	81.5	50.7	35.0	100
Wood	109.4	25.4	67.7	43.5	52.9	100
Pulp and paper	100.9	27.9	85.9	54.7	55.2	100
Coke and petroleum	197.7	60.1	135.7	209.4	47.7	100
Chemicals	98.0	23.3	80.9	51.1	41.1	100
Plastics	74.9	12.4	64.0	49.9	26.8	100
Other non-Metallic	91.2	23.3	72.7	52.6	61.1	100
Basic metals	78.2	18.1	62.3	36.8	40.3	100
Machinery	74.6	6.2	63.1	39.1	22.8	100
Electrical	75.0	11.6	56.8	34.2	29.0	100
Transport	58.2	23.6	47.7	30.3	25.2	100
Manufacturing	88.3	17.3	76.9	46.4	29.6	100

Notes:

To make figures easily readable, table reports the exponential values of (3.9). Productivity levels are expressed relative to Germany. For example, Spain's RTFP in Food industry is 70 % of the Germany's RTFP in this industry. Similar interpretations are applied to all figures presented in the table

Chapter 4

Sources of TFP Growth in a Framework of Convergence: Evidence from Greece

4.1 Introduction

In the field of development economics a large number of studies have attempted to understand the sources of economic growth. Solow's influential study (1957) for instance, which develops the concept of the residual in an aggregate production function, is a case in point. Solow's approach exemplifies that the real sources of technical change are disembodied from inputs of production, implying that technological progress is not included in the flows of labour and capital. Accordingly, in Solow's terminology, the real sources of technical change are exogenous.

In a standard production function of the form $Q_t = A_t F(K_t, L_t)$, any shift in the Hicks- neutral technical parameter is "costless" highlighting the feature of a disembodied technical change. This is why parameter A is referred to as the "Manna of Heaven". In a more realistic setting, the above formulation gives the opportunity to estimate econometrically the contribution of the other factors to shift technology over time. Hulten (2000) provides a short biography of the formulation and many standard issues involved in modelling the productivity parameter A derived from the Solow benchmark model.

The "new" growth theory, also known as the endogenous growth theory, provides us with some new insights in our effort to understanding the sources of economic growth (Aghion and Howitt (1998)). As its name implies, this theory relies on the assumption that the determinants of growth are endogenous considering that technological advancements are embodied in the inputs of production. One of the differences between the neoclassical and the endogenous growth theories refers to a different assumption about the behaviour of the capital input. In the neoclassical setting, capital is subject to diminishing returns and along with the assumption of identical technology and preferences

across countries then poor countries tends to grow faster relative to rich ones. Baumol (1986) fails to find evidence of convergence between poor and rich countries attributing this failure to the misspecified assumption about the behavior of capital as suggested by the neoclassical growth theory. Romer (1986, 1990), one of the most important contributors of the endogenous growth theory, neglects the assumption of diminishing returns to capital specifying a linear relationship between investment and output.

The endogenous growth theory gives particular emphasis to investment, which is associated with a bigger variety of capital goods. A key feature of the endogenous growth model is the role of knowledge accumulation as an engine of economic growth. In an endogenous growth model, the technical change – the parameter A in the Solow production function- is not a measure of our ignorance; instead, it is embodied in the factors of production and it is subject to an interplay between the structure of the economic system and the production process.

Neoclassical and endogenous growth theories are not contradictory with each other. Both demonstrate convincingly the importance of studying technology (Sharpe (2002a)) but endogenous growth theory provides a more insightful and systematic analysis of the sources that influence technological progress. Along with the accumulation of capital (both physical and human), some new concepts have been added in the agenda of economic growth, with the most prominent those of trade and innovation. Greater trade openness leads to competition that encourages the adoption of new technologies resulting in greater productivity. Trade can also serve as a transmitter of new ideas and information that can be reflected in higher rates of productivity growth. Furthermore, innovative activity can generate new inventions and processes contributing to a more efficient use of the existing resources and hence to higher productivity. These theoretical arguments are not always supported by the empirical evidence stimulating further research in the field of economic growth (Romer and Frankel (1999)). The main focus of this research agenda is to identify the mechanisms through which trade and innovative activities can affect meaningfully the rates of productivity growth.

The main aim of the present chapter is to investigate the sources of productivity growth in Greek manufacturing industries. To do so, the analysis uses as a departure point, some key propositions of the endogenous growth theory. However, the novelty of the present chapter is that it analyses the sources of Total Factor Productivity (henceforth TFP) Growth using a framework of convergence⁶⁶ between a non-frontier country, which is Greece, and a frontier country, which is Germany. The aim of using this methodology is to assess the importance of technology transfer as a source of productivity growth for a country, which does not always act as a technology leader.

The potential of convergence as a source of productivity growth is initially developed by Bernard and Jones (1996a, 1996b) specifying a model that carries some similar characteristics with the traditional income convergence literature. Redding et al. (2005) and Cameron (2006) adopt this model to explain the sources of TFP growth in UK manufacturing considering US as the frontier country. Other important contributions to the empirical validity of the productivity convergence model made by Griffith et al. (2004) for a group of OECD countries, Cameron (2005) for Japan and US and Khan (2006) for France and US. The similarity of these studies is that the frontier country is mainly US while the non-frontier countries are developed countries that their productivity falls behind only compared to US. The pair of countries considered in the present study differs considerably from the pair of countries used in the existing literature. As we have already seen in Chapter 3, Germany is the European productivity leader while Greece is an outlier. From another point of view, Greece belongs to the peripheral spectrum of the European Union and certainly the potential of technology transfer is large but the crucial question posed is to quantify the contribution of technology transfer as a stimulus of productivity growth.

⁶⁶ Technology transfer at the industry level is measured by a relative index of TFP between Greece and Germany. The present concept of convergence is not identical to the classical idea of β and σ convergence as used in the cross-country growth literature (Barro and Sala-i-Martin (1995)). The difference is that β convergence, for example, is concerned with the relationship between a country's growth rate and its initial per capita income, while in the present study convergence refers to industry's TFP growth and its initial distance from the frontier. Redding et al. (2005) provide a detailed discussion regarding the similarities of the present concept of convergence with the classical ideas of σ and β convergence.

Despite the small number of studies that analyse TFP convergence, the latter issue is of special interest from a policy-making point of view, especially for the ongoing process of European economic integration. A number of structural changes have taken place in the European Union within the last fifteen years, such as the removal of trade barriers, the use of a common currency, and the establishment of a common economic policy for a number of issues.⁶⁷ The main objective of the above set of policies is to accelerate economic integration across European member states. A coherent and integrated Europe without commercial constraints minimizes transaction costs, risks and uncertainties providing a great opportunity to less developed countries to converge in a more rapid pace towards the economic level of more developed EU countries.

The present study has three main goals. Firstly, it seeks to enrich the literature of TFP convergence using a lengthy panel from 1980-2003 quantifying the speed of convergence for a traditionally non-frontier economy like Greece. Secondly, it provides evidence for the impact of factors indicated by the endogenous growth theory (i.e. R&D investment, trade and human capital) on TFP growth of Greek manufacturing industries. Thirdly, the present study introduces some variables, as potential sources of productivity growth that have attracted little attention in the productivity convergence literature. These variables are labour market rigidities and product market concentration that mainly reflect the condition of the domestic market and its impact on productivity growth.

The chapter is organized as follows: section 4.2 discusses in more detail the sources of productivity growth and provides a brief review of the important contributions made in the lengthy literature of productivity growth. Section 4.3 presents the analytical framework of the convergence scenario and discusses the measurement of TFP. Section 4.4 shows the method used to measure TFP. Section 4.5 presents the econometric specification of the analysis and the main results. Section 4.6

⁶⁷ This set of changes includes the harmonization of the fiscal policy rules and the existence of a common monetary authority.

provides a sensitivity analysis checking for the robustness of the principal findings and section 4.7 outlines the main points analysed in the chapter.

4.2 Literature Review: Theory and Evidence

4.2.1 Main Sources of TFP Growth

A body of empirical work has examined the relationship between R&D-the principal source of innovation- and productivity growth. Studies that confirm a positive effect of R&D investment on productivity growth include Griliches (1980) and Griliches and Lichtenberg (1984) among many others. These studies use evidence either from firm or from country level data to highlight the fact that domestic investment can act as a conduit for productivity improvements and cost reductions.⁶⁸ Grossman and Helpman (1991) and Coe and Helpman (1995) address the issue whether R&D investment initially conducted abroad can serve as a source of productivity growth in other countries. Evidence provided by the above papers verifies that gains from R&D are multifaceted. A country can gain from its own R&D effort but can also benefit from the R&D effort of other countries. The debatable issue in the literature regarding the influence of R&D on productivity growth refers to the accurate mechanism through which gains from R&D initially conducted abroad are transmitted across countries.

One of the most prominent scenarios is that foreign R&D is diffused to other countries via trade. When a trade partner devotes substantial resources in R&D activities then the importing country can have multiple benefits from trade. The first set of gains stresses the importance of static gains derived from specialisation and the improvements in the economic welfare of the importing country. The second set comprises of dynamic gains derived from imitation of new technology, which is

⁶⁸ Linking this argument with stylized facts at the industry level, Spence (1984) assumes that a firm's R&D investment provides positive spillovers in the performance of rival firms within the industry, leading to an increase in industry's overall performance. Simultaneously, spillovers generate free-rider problems affecting negatively the decision of a firm to invest in R&D. This feature of diminishing returns of R&D is more systematically explored in the sensitivity tests conducted later in this chapter.

incorporated in the imported commodities. For the dynamic effect to occur, trade should take place in raw intermediate inputs rather than in final goods. The above effects are summarised to the learning-by-importing hypothesis.

Exports can also generate some important positive spillovers. The static benefit of exporting is the exploitation of economies of scale due to market expansion. In a more dynamic perspective, exporting offers domestic producers the opportunity to have contacts with international best practices (i.e. this effect is known in the corresponding literature as the learning-by-exporting effect). The set of dynamic gains carries many similar characteristics with gains acquired from pure exercises of learning-by-doing.

As far as the empirical evidence of the above hypotheses is concerned, Keller (1998) provides robust evidence for the learning-by-importing hypothesis. Additionally, evidence from Keller (2000) reveals that the composition of the imported commodities also matters for productivity growth. The evidence of this study indicates that imports facilitate the outcomes of R&D activity undertaken in the foreign country, which are also beneficial for the domestic market of the receiving country. The empirical evidence of the learning-by-exporting hypothesis is vague. Clerides et al. (1998), Bernard and Jensen (1999a, 1999b) and Ahn (2001) reveal that higher export involvement does not increase firm productivity. A similar result is found in Xu (1996) with the use of country level data.⁶⁹ A possible reason for the lack of evidence concerning the learning-by-exporting hypothesis could be the causal nature of the two variables. The current research agenda addresses the question whether exporting improves productivity; while, the true causality might run from productivity to exporting and not vice versa. Empirical support for the hypothesis that productivity leads to exporting is found in Clerides et al. (1998) and Bernard and Jensen (1999a, 1999b and 2004b), who view it as an evidence in favour of

⁶⁹ Evidence for the learning-by-exporting hypothesis at the industry level is rather limited. Some recent studies that they have analysed the issue using industry data are Anderson (2001) and Fu (2005). Findings appear to be rather contradictory; the former study finds positive exporting effects of productivity growth for Swedish manufacturing industries while the latter finds no evidence for Chinese industries.

the self-selection hypothesis. Accordingly, good firms (in terms of productivity) are those that become exporters.⁷⁰

In the discussion so far, special emphasis has been given to the role of trade as a technology transmitter of foreign innovation (i.e. innovation that is initially developed abroad). But, the scenario regarding the contribution of R&D to productivity growth is incomplete if one ignores the multifaceted role of domestic innovation. The standard impact of domestic R&D is to accelerate the growth of productivity but, even if this direct effect is weak, domestic innovation is essential since it guarantees that the economy has the minimum level of technical expertise and technological “know-how” to absorb technological advancements from abroad. Cohen and Levinthal (1989) suggest that R&D enhances the firm’s ability to assimilate and exploit the existing information. Acemoglu and Zilibotti (2001) stress a similar role of complementarity between technological transfer and human capital on stimulating productivity growth. Griffith et al. (2004) systematically address the multifaceted role of domestic R&D in a panel of OECD countries showing that domestic R&D improves substantially the absorptive capacity of the domestic economy.

4.2.2 Labour and Product Market Distortions as Sources of TFP Growth

The previous discussion stresses the role of some stylized facts in the research agenda of productivity growth. The present study expands the analysis addressing the role of institutional factors on productivity growth. In cross-country studies (Scarpetta et al. (1999)), a standard approach is to use specific indices in order to measure the degree of stringency in labour and product markets and after to

⁷⁰ Certainly, there are studies in which the results indicate that the causality runs from exporting to productivity (see Kraay (1999) and Castellani (2002)). To estimate the real direction of the exporting-productivity causation is a complex econometric issue, which requires panel data sets with very long time spans. The fulfillment of this requirement is very crucial if one seeks to obtain a clear view for whether exporting Granger-causes productivity improvements or vice versa. The fact that many studies do not accomplish this characteristic explains somehow why there is divergence in the existing empirical findings. Apart from the pure econometric technicalities, the lack of evidence for the learning-by-exporting hypothesis is attributed to the different nature of the case studies used in the analysis. For instance, in a highly industrialised country, which is very close to the international frontier there is little scope for knowledge spillovers, while in less developed countries, (which are distant from the frontier) the margin for substantial knowledge spillovers is bigger.

evaluate their impact on productivity growth. In the current case study, these indices are of minor importance as they do not vary across industries within a country.

In the case of Greece, the impact of labour market distortions on productivity growth is measured by the minimum wage. It is widely accepted that a flexible labour market allows labour inputs to move quickly and costless within the economy thereby contributing to an efficient allocation of the resources, which in return can generate positive productivity shifts. The vital question concerning minimum wage policy is whether the benefits gained from the insiders of the labour market can offset the losses burdened to the outsiders (i.e. unemployment). There is relatively little research to shed light to whether minimum wage has an effect on productivity.

The minimum wage is defined as the minimum daily wage paid for an unqualified worker divided by the median wage in the whole manufacturing. Data for the minimum wage in Greece are taken by OECD-Labour Market Database. The minimum wage in Greece is determined through a collective bargaining agreement. In the first years of the sample, beginning of 1980's, the ratio of minimum to median wage in Greece, was the highest within the group of OECD countries (Table 1 in Neumark and Wascher (2004)). The conservative government elected in the beginning of 1990's passed a new law to reduce the state intervention in the industrial relations resulting in the decrease of minimum wage, which stabilised around the mean of the minimum wage in the group of OECD countries.

The high minimum wage in Greece during 1980's designates mainly two conditions, the bargaining power of trade unions and the active role of the welfare state. Under the presence of powerful trade unions, the agreed minimum wage was greater than the competitive wage in many industries resulting in an increase in labour costs and thereby a decline of productivity growth. Regarding the role of the welfare state, during 1980's the principal aim was to narrow the wage differentials with the function of an automatic pay adjustment (known as ATA) system compensating low income earners for erosion in real wages. The ATA system led to remarkable increase in unit labour costs. This system abolished in 1991 but trade unions have maintained their strong bargaining

power, which is in many cases a crucial obstacle for the implementation of structural reforms that favour a more flexible labour market. Overall, in the period under study the Greek labour market is overprotected leading to high labour costs and high unemployment particularly for young workers. As a result, employers have been reluctant to hire labour, which reduces considerably their ability to respond quickly and effectively to exogenous shocks.

Turning to the conditions of product market, the fundamental argument in economics is that perfect competition is the ideal type of market structure because it ensures an efficient allocation of resources and maximises the surplus of both consumers and producers. This argument is widely highlighted to support the positive link between competition and productivity performance. Vickers (1995) points out that innovation is generally promoted more effectively in competitive markets since a share of the efficiency gains are devoted to innovative activity. Nonetheless, the productivity-competition relationship should be treated with special care since its empirical confirmation is not always clear due to the endogeneity nature of the two variables. Nickell (1996) argues that if a firm is initially productive then it gains a larger share of the market in the long-run. However, the evidence from his study suggests that market power generates a reduced level of productivity and, more importantly, that an increased degree of competition is associated with higher rates of TFP growth. Tsekouras and Daskalopoulou (2006) provide evidence for Greek manufacturing industries, which does not confirm Nickell's findings. Precisely, Tsekouras and Daskalopoulou's study proves that higher degree of concentration in the market does not necessarily lead to more slack, confirming Caves' (1987) argument that efficiency in the market is independent from the degree of concentration. Which of the above arguments is consistent with the current data set is an issue examined in the empirical section together with a more detailed description of the variable used to measure market concentration.

4.3 Analytical Framework

This section presents the theoretical framework from which an econometric specification is derived. The present framework replicates the main settings of prior models in the productivity convergence literature (Bernard and Jones (1996a, 1996b) and Redding et al. (2005)). Consider a world with only two countries $c \in \{G, F\}$, producing an output in industry i at time t . Production is characterised by constant returns to scale and takes the form of a Cobb-Douglas production function:

$$Y_{c,i,t} = A_{c,i,t} f(K_{c,i,t}, L_{c,i,t}) \quad (4.1)$$

Y measures value added and the inputs include capital stock K , labour L . Parameter A represents a measure of technical efficiency as in Solow's study, and differs across countries and industries. In the empirical analysis, the efficiency parameter is approximated by an index of Total Factor Productivity (TFP). The above production function is homogenous of degree one and exhibits diminishing marginal returns to the production inputs.

For the purposes of the present analysis, at a given point in time t , one of the countries c will have a higher level of TFP and thus this country is specified as the "technological frontier" economy indexed by F (Redding et al.(2005)), in the present empirical model this country is Germany and the follower economy is Greece denoted by G . The sensitivity analysis of the chapter proves that a different choice of the frontier economy does not change the picture of the empirical results.

In Bernard and Jones (1996a, 1996b), $A_{c,i,t}$ is primarily modelled as a function of either domestic innovation or technology transfer from the frontier country. Therefore, a general formulation of the efficiency parameter A or equivalently the Total Factor Productivity (TFP) in industry i of country G is:

$$\Delta \ln A_{i,G,t} = \gamma_{i,G,t} + \lambda_{i,G} \ln \left(\frac{A_{i,F,t-1}}{A_{i,G,t-1}} \right) \quad (4.2)$$

In equation (4.2) parameter γ represents the rate of innovation, which depends on industry-specific factors while parameter λ denotes the change in TFP with respect to technology transfer from the frontier. As it stands, the ratio in the right-hand side - $\left(\frac{A_{i,F,t-1}}{A_{i,G,t-1}} \right)$ - indicates that the higher is the gap in industry i from the frontier economy the greater is the potential for productivity growth through technology transfer. For the frontier economy, productivity growth depends only on domestic innovation and thus the second term in the right-hand side of (4.2) is zero:

$$\Delta \ln A_{i,F,t} = \gamma_{i,F,t} \quad (4.3)$$

Subtracting equation (4.3) from (4.2), it yields the following relationship:

$$\Delta \ln \left(\frac{A_{i,G,t}}{A_{i,F,t}} \right) = (\gamma_{i,G,t} - \gamma_{i,F,t}) + \lambda_{i,G} \ln \left(\frac{A_{i,G,t-1}}{A_{i,F,t-1}} \right) \quad (4.4)$$

Equation (4.4) can be viewed as an Equilibrium Correction Model (ECM) with a long-run steady state relative TFP. Assuming that in the long-run $\Delta \ln \left(\frac{A_{i,G,t}}{A_{i,F,t}} \right) = 0$ then the steady state equilibrium is given by:

$$\ln \left(\frac{\bar{A}_{i,G}}{\bar{A}_{i,F}} \right) = \frac{\gamma_{i,G} - \gamma_{i,F}}{\lambda_{i,G}} \quad (4.5)$$

Equation (4.5) states that in the steady state equilibrium, relative TFP depends on the rates of innovation in the non-frontier economy G , in the frontier economy F and on the speed of technological convergence λ that occurs between the two economies.

Another inference that can be made from equation (4.5) is that country G remains technologically behind in steady state equilibrium, that is, $\ln \left(\frac{\bar{A}_{i,G}}{\bar{A}_{i,F}} \right) < 0$ as long as $\gamma_{i,G} < \gamma_{i,F}$. In other words, these inequalities describe that in the steady state equilibrium technological frontier country F remains as such as long as its rate of innovation is higher than the rate of innovation in country G . Finally, the factors that affect $\gamma_{i,G,t}$ and $\lambda_{i,G,t}$ in (4.2) are mainly derived from endogenous growth theory, namely R&D, trade, human capital, labour market rigidities and domestic market concentration. Appendix C4.1 provides a discussion about the data sources and Appendix C4.2 shows the definition of variables and summary statistics. The next section is devoted to define the measure of productivity, which is the key variable of the chapter.

4.4 Measuring Total Factor Productivity

As mentioned before, the measure of productivity used in the present study is total factor productivity (TFP). The calculation of this index is based on a superlative index number approach developed by Caves et al. (1982). This index can be derived directly by a flexible translog production function (i.e. a more general case than a standard Cobb-Douglas function) and it is superlative since it is a close approximation of an arbitrary, twice differentiable production function with constant returns to scale. The TFP growth in industry i is defined as:

$$\ln\left(\frac{A_{i,c,t}}{A_{i,c,t-1}}\right) = \ln\left(\frac{Y_{i,c,t}}{Y_{i,c,t-1}}\right) - a_{L,t} \ln\left(\frac{L_{i,c,t}}{L_{i,c,t-1}}\right) - (1 - a_{L,t}) \ln\left(\frac{K_{i,c,t}}{K_{i,c,t-1}}\right) \quad (4.6)$$

where $c=G$ (Greece), F (Germany).

Output Y is measured by value added, L is a measure of labour input and K denotes capital stock constructed by accumulating investment flows in capital assets. The input measures in equation (4.6) are weighted by their shares in value added under the assumption of constant returns to scale. The

labour share is defined as: $a_{L,t} = \frac{a_{i,c,t} + a_{i,c,t-1}}{2}$. The main data provider for the calculation of TFP is

OECD-STAN.

A crucial issue in comparing industry's TFP across countries is to express output and inputs in a common currency. O' Mahoney (1996) presents that relative TFP levels differ substantially according to the conversion method used. A common methodology is to use an aggregate Purchasing Power Parity (PPP) exchange rate based on prices of final expenditure. However, this aggregate method of conversion does not reflect differences in retail prices across industries as well as it does not provide information for the distribution of output across industries (van Aark and Trimmer (2001)). An industry

specific conversion factor seems more suitable to the present exercise but the only database (i.e. GGDC-International Comparison of Productivity Program (ICOP)) with industry conversion factors reports data only for 1997. Consequently, the standard aggregate method is followed by applying the GDP-PPP conversion factor that expresses national currency per international USD. The latter data are obtained from World Bank indicators under the International Comparison Project (ICP). After converting data to a common currency, sector-specific deflators are utilised to correct for price changes. OECD-STAN provides specific deflator indices for value added and investment in capital assets.⁷¹ Therefore, the output and input values appeared in (4.6) are expressed in constant prices of 1995.

As stated in equations (4.2) and (4.4) of the previous section, apart from industry i 's TFP growth, another index is necessary to represent industry i 's TFP in Greece relative to industry i 's in Germany. The relative index of TFP level is defined as:

$$\ln \left(\frac{A_{i,G,t-1}}{A_{i,F,t-1}} \right) = \ln \left(\frac{Y_{i,G,t-1}}{Y_{i,F,t-1}} \right) - a_{L,t} \ln \left(\frac{L_{i,G,t-1}}{L_{i,F,t-1}} \right) - (1 - a_{L,t}) \ln \left(\frac{K_{i,G,t-1}}{K_{i,F,t-1}} \right) \quad (4.7)$$

where G and F are Greece and Germany, respectively and the labour share is now defined as:

$$a_{L,t} = \frac{a_{i,G,t-1} + a_{i,F,t-1}}{2}.$$

The construction of capital stock in both countries is based on a perpetual inventory method given by the following formula: $K_{i,c,t} = (1 - \delta)K_{i,c,t-1} + I_{i,c,t-1}$, where the Greek letter δ denotes the capital depreciation rate, defined at the 10% for all industries and I stands for the investment in gross fixed

⁷¹ Data for gross fixed capital formation, capital deflator, number of employees and value added deflator for years prior to 1995 are taken from KLEMS database; an appendix provides a detailed summary of data sources.

capital assets.⁷² The initial capital stock is computed from the following formula: $K_{i,c,1980} = \frac{I_{i,c,1980}}{g_i + \delta}$,

where $c = G, F$ and g is the average growth rate of industry i 's investment over the whole period. The first year with available data in gross fixed capital investment is 1980.

A consistent measurement of TFP requires that the index used controls for a number of issues that reflect some particular characteristics of the productivity variable. The first issue refers to the cyclical character of productivity indicating that the productivity residual as specified in the aggregate Solow model tends to follow the movements of the business cycle; in periods of expansion, productivity is unusually large while in periods of recession it is low or even negative (Hall (1990)). To control for the cyclical nature of productivity, the input of capital stock is adjusted for fluctuations in capacity utilisation. A second adjustment is to express the labour input in equations (4.6) and (4.7) in hours worked rather than in number of employees. Therefore, the number of employees is multiplied by the annual number of hours worked per employee in each industry.⁷³ One last issue concerning a consistent measurement of TFP is to adjust TFP for quality differences in the labour input. This requires information about the number of skilled and unskilled workers as well as information about their wages. Unfortunately, these data do not exist for Greek manufacturing industries for the whole period under study and thus labour is measured as a homogenous input. After the adjustments discussed above the final TFP growth index takes the following form:

$$\ln \left(\frac{A_{i,c,t}}{A_{i,c,t-1}} \right) = \ln \left(\frac{Y_{i,c,t}}{Y_{i,c,t-1}} \right) - a_{L,t} \ln \left(\frac{\tilde{L}_{i,c,t}}{\tilde{L}_{i,c,t-1}} \right) - (1 - a_{L,t}) \ln \left(\frac{\tilde{K}_{i,c,t}}{\tilde{K}_{i,c,t-1}} \right) \quad (4.8)$$

where $c=G, F$; $\tilde{L}_{i,c,t} = h_{i,c,t} L_{i,c,t}$; $\tilde{K}_{i,c,t} = u_{c,t} K_{i,c,t}$.

⁷² A similar formula is also used to construct capital stock for Germany.

⁷³ Data for hours worked per employee in each industry are taken from the Groningen Growth and Development Centre (GGDC)-60 Industry database.

Letters h and u denote the average annual hours worked and the percentage of capacity utilization, respectively.⁷⁴ No industry-specific information is available for the rate of capacity utilization, thus data for the whole manufacturing sector are used. The use of an aggregate capacity utilisation measure presupposes that the business cycle effect is fixed across industries. Such an assumption is not necessarily true taking into account that the size of the business cycle effect is proportionate to the industry capital–labor ratio and the level of technology.⁷⁵

Annual TFP growth rates of the aggregate manufacturing sector for both Greece and Germany are shown in Table (4.1) along with the relative TFP level between the two countries. In order to ensure that the above figures are not driven by outliers, a test is implemented to detect for extreme values.⁷⁶ After dropping outliers, the results show that the Greek manufacturing sector has grown on average by 16.84% over the sample period while the German manufacturing has clearly experienced a lower rate of productivity growth equal to 1.86%. This preliminary evidence indicates that the non-frontier country grows faster confirming the core proposition of the neoclassical theory of convergence. The last column of Table (4.1) verifies that Germany is correctly taken as the “technological frontier” country since the TFP level in German industries is always higher. Figures in the last column can be interpreted in the following manner: Greek manufacturing was only 2.81% percent as productive as that of Germany in 1980, while in the last year of the sample the Greek TFP level is more than the half of the German one (i.e. 56.24%).

⁷⁴ Capacity utilisation data are obtained from OECD-Main Economic Indicators and are provided on a quarterly basis.

⁷⁵ The fact that the current TFP measure does not control for industry–specific rate of capacity utilisation and different composition of labour skills might cause important difference in the measure of TFP across countries. A similar argument appears in Andersson (2001) and Redding et al. (2005). However, these problems cannot bias the econometric results since they can be effectively tackled in a fixed effects econometric specification.

⁷⁶ The test for outliers is undertaken in STATA 9 under the command `hadimvo`. The total number of observations dropped is eighteen.

Table 4.1 TFP Growth (Equation (4.8)) and Relative TFP Levels (Equation (4.7))

Year	<i>TFPG</i>_{Germany}	<i>TFPG</i>_{Greece}	<i>RTFP</i>
1980	Not Defined	Not Defined	2.81%
1981	-4.70%	25.38%	3.16%
1982	1.29%	32.43%	3.68%
1983	3.23%	30.26%	5.46%
1984	0.82%	28.99%	7.70%
1985	2.75%	27.57%	10.08%
1986	6.29%	22.29%	9.79%
1987	1.18%	12.35%	9.76%
1988	2.56%	32.17%	13.26%
1989	1.34%	23.23%	15.32%
1990	5.84%	18.07%	17.35%
1991	4.52%	26.19%	25.93%
1992	-0.14%	13.07%	25.11%
1993	3.04%	22.45%	37.92%
1994	2.39%	12.56%	36.33%
1995	1.07%	7.79%	39.67%
1996	4.24%	8.64%	40.27%
1997	1.26%	2.36%	40.37%
1998	1.29%	12.22%	44.58%
1999	1.98%	0.90%	44.33%
2000	-0.60%	9.03%	48.51%
2001	1.36%	7.05%	48.07%
2002	4.12%	6.34%	48.97%
2003	-5.82%	11.36%	56.24%
Mean	1.86%	16.84%	26.12%

Notes:

TFPG is an index of TFP growth adjusted for capacity utilization and hours worked. RTFP is an index of Relative TFP level between Greece and Germany. Figures displayed in the table are the exponential values of equation (4.8)

Table (4.2) reports the values of relative TFP at the first and the last year of the sample. Similar evidence is shown in figure (4.1), which shows the time trends of relative TFP of all industries included in the study. The first remark that should be done from this evidence is that Germany maintains a clear technological leadership in all industries both in the beginning and at the end of the period. Nonetheless, the figures reported indicate a clear evidence of convergence. In 1980, the Greek manufacturing industries had less than 10% of the TFP of their German counterparts. At the end of the period, this productivity gap has closed substantially and in six out of the seventeen industries, Greece is more than 70% as productive as Germany (i.e. food, pulp paper, rubber and plastics, electrical machinery, motor vehicles and other manufacturing). A particular characteristic of Figure (4.1) is that

Group A that include low-technology industries tend to converge faster than any other group of industries of the sample. Yet, there are industries in which Greece needs to accelerate the speed of catch up since the relative TFP remains below 50% even at the end of the period (i.e. textiles, coke, basic metals, fabricated metals and communication equipment). The fact that some industries tend to catch up faster than some other domestic counterparts reflects somehow the existence of different structural patterns across industries. For instance, in the period under study, one of the largest firms in the coke industry belongs to the state highlighting the monopolistic nature of the industry and the strong potential for slack that possibly slows down the rate of productivity growth. In contrast, in the food industry many structural reforms have been undertaken in the period under study stimulating faster rates of productivity growth. The econometric analysis of the next section investigates systematically, among others, the importance of technological transfer as a source of productivity growth.

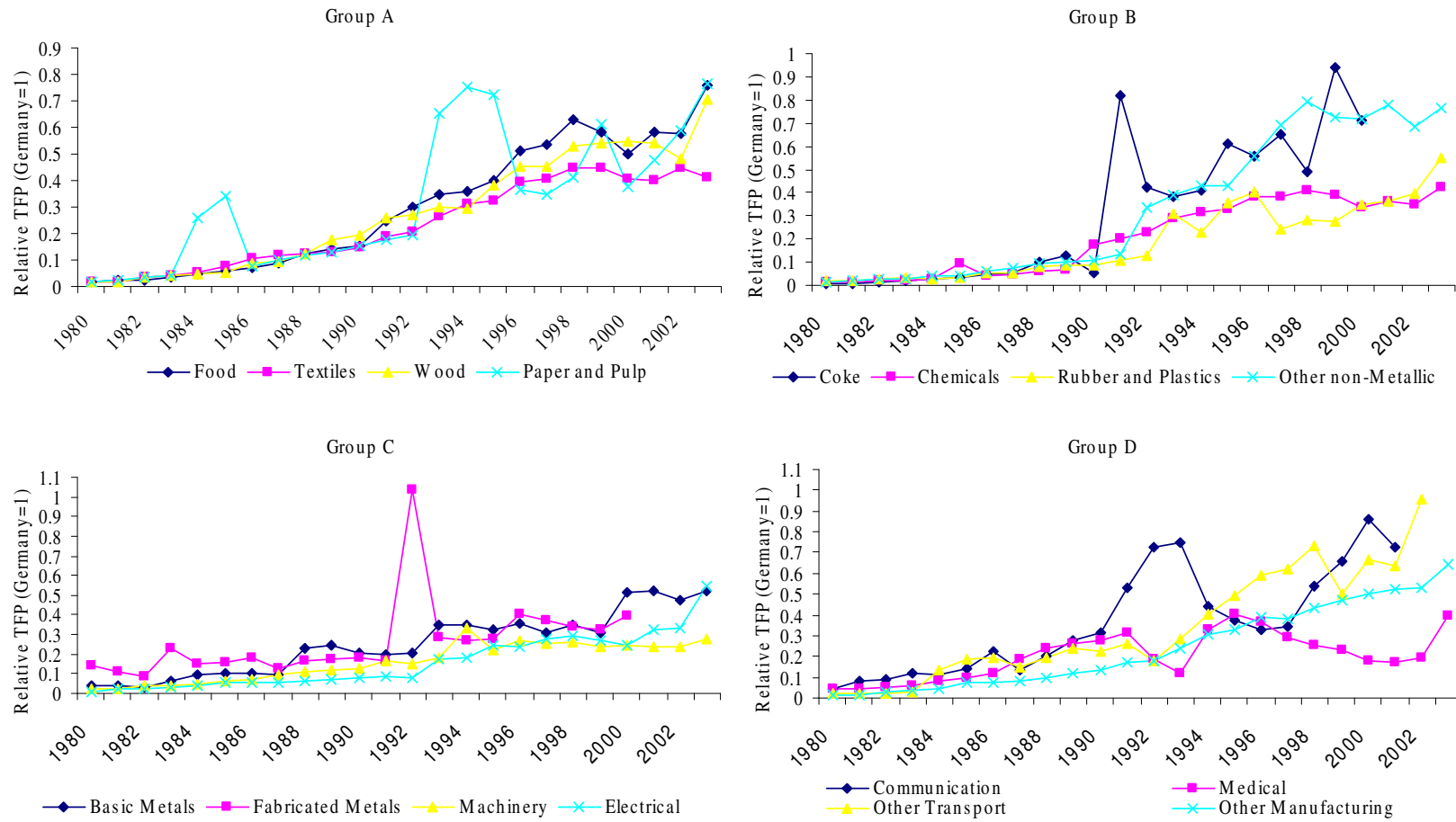
Table 4.2 Relative TFP in 1980 and 2003

Industry	1980	2003
Food Products, Beverages and Tobacco	2.38%	76.11%
Textiles, Textile Products, Leather and Footwear	3.37%	40.95%
Wood and Products of Wood and Cork	3.44%	70.61%
Pulp, Paper, Paper Products, Printing and Publishing	3.61%	76.34%
Coke, Refined Petroleum Products and Nuclear Fuel	1.21%	42.08%
Chemicals and Chemical Products	1.74%	54.86%
Rubber and Plastics Products	2.94%	76.34%
Other Non-metallic Mineral Products	2.43%	51.86%
Basic Metals	3.44%	39.71%
Fabricated Metal Products, except Machinery and Equipment	8.88%	27.60%
Machinery and Equipment	3.63%	54.28%
Electrical Machinery and Apparatus	2.59%	72.59%
Radio, Television and Communication Equipment	9.12%	39.83%
Medical, Precision and Optical Instruments, Watches and Clocks	5.13%	64.20%
Motor Vehicles	2.00%	76.11%
Other Transport Equipment	2.26%	40.95%
Manufacturing nec	2.72%	70.61%

Notes:

The table displays the exponential values of equation (4.7) for the first and the last year of the sample. TFP values are adjusted for capacity utilization and the number of hours worked

Figure 4.3 Relative TFP of Greek Manufacturing, (Germany=1)



4.5 Econometric Model and Results

The present section specifies the econometric model applied to estimate the sources of productivity growth in Greek manufacturing industries. The econometric model is based on the theoretical concepts already presented giving emphasis to the catch-up process between industries across countries. Following Bernard and Jones (1996a), the empirical convergence equation is an equilibrium correction model (ECM) represented by an ADL (1,1) process,⁷⁷ in which the level of productivity in industry i is co-integrated with productivity in the frontier country F as follows:

$$\ln A_{i,G,t} = \beta_0 + \beta_1 \ln A_{i,G,t-1} + \beta_2 \ln A_{i,F,t} + \beta_3 \ln A_{i,F,t-1} + \omega_{i,G,t} \quad (4.9)$$

where ω stands for all the observed and unobserved effects that may influence $A_{i,G,t}$ (i.e. TFP in the non-frontier country) and it is further decomposed as:

$$\omega_{i,G,t} = \sum_k \gamma_k Z_{i,G,t-1} + \rho_i + d_t + e_{i,G,t} \quad (4.10)$$

The summation in the right-hand side of (4.10) includes all the observed factors affecting TFP while ρ and d stand for industry and year specific effects, respectively. Assuming that the long-run homogeneity $(1 - \beta_1 = \beta_2 + \beta_3)$ holds in (4.9), then its transformation gives:

$$\ln \Delta A_{i,G,t} = \beta_0 + \beta_2 \ln \Delta A_{i,F,t} + (1 - \beta_1)(\ln A_{i,F,t-1} - \ln A_{i,G,t-1}) + \omega_{i,G,t} \quad (4.11)$$

The dependent variable in equation (4.11) is industry i 's TFP growth in Greece- the non-frontier economy- including in the right hand-side the industry i 's TFP growth in Germany -the frontier economy- and a term of technological gap in industry i between Germany and Greece. The

⁷⁷ Further details about estimation issues of an ADL (1, 1) model can be found in Pesaran and Shin (1995) and Hendry (1995).

substitution of (4.10) into (4.11) yields a specification in which R&D, trade and human capital influence the rate of TFP growth in the non-frontier economy both directly and through the rate of absorptive capacity. After these considerations, the estimatable equation takes the following form:

$$\ln \Delta A_{i,G,t} = \rho_{i,G} + \alpha \ln \Delta A_{i,F,t} + \gamma Z_{i,G,t-1} + \lambda \left(\ln \frac{A_{i,F,t-1}}{A_{i,G,t-1}} \right) + \mu Z_{i,G,t-1} \left(\ln \frac{A_{i,F,t-1}}{A_{i,G,t-1}} \right) + e_{i,G,t} \quad (4.12)$$

In (4.12), $\rho_{i,G}$ controls for industry's individual heterogeneity, α captures the impact of TFP growth in the frontier economy on the non-frontier economy, λ indicates the speed of technology transfer, Z includes other factors that have a direct effect on TFP growth such as: R&D, trade, human capital, labour market rigidities and market concentration and μ measures the responsiveness of TFP growth after changes in the level of absorptive capacity. The latter variable is represented by the interacted term between variables included in Z and TFP gap.

Equation (4.12) is a fixed effects specification; the term $\rho_{i,G}$ stands for time-invariant industry dummies. A possible method to estimate (4.12) is to use a least squares dummy variable approach (LSDV), which is an OLS, with a set of dummy variables. A potential problem regarding the LSDV approach is that industry fixed effects might be correlated with other covariates of the right hand-side leading to biased estimates. A Within-Group Fixed Effects (FE) estimator eliminates $\rho_{i,G}$ by expressing all variables as deviations from their industry means. According to Nickell (1981), the order of the bias emerged from the use of the FE estimator is of order $1/T$, where T is the number of years. Therefore, in panels with a relatively large number of time series the bias tends to be zero. Evidence from Monte Carlo experiments (Judson and Owen (1999)) shows that if $T > N$, where N is the number of cross-sections then a FE estimator performs better than the Instrumental Variable (IV)-GMM estimator. In the current sample, after missing two years required for the construction of some variables, the panel consists of 22 years and 17 industries indicating that the FE within group estimator is a better choice than GMM.⁷⁸

⁷⁸ The crucial dilemma faced by the researcher in estimating a dynamic panel data model, as this specified in (4.12), is to assess the cost of reducing the correlation bias emerged between the lagged dependent variable and the fixed effects. Judson and Owen (1999) consider three different alternatives to correct this bias. Their

Table (4.3) presents results from a FE estimator, the dependent variable is the growth rate of total factor productivity (i.e. $\Delta \ln A_{i,G,t}$) in Greek manufacturing industries and the right-hand side in each specification includes four explanatory variables. This table reports a set of standard specification tests concerning the behaviour of the error-term $e_{i,G,t}$. Firstly, the modified Wald test refers to whether the error term has a constant variance across industries, $Var(e_{i,t}) = \sigma_i^2$. Secondly, the Pesaran (2004) test is reported for cross-sectional dependence of the residuals, $Cor(e_{i,t}, e_{k,t}) \neq 0$ for any industry $i \neq k$. These tests indicate that heteroscedasticity and cross-sectional correlation are present in the current sample. Finally, two alternative tests for first order serial correlation $Cor(e_{i,t}, e_{i,t-1}) \neq 0$ are implemented based on Wooldridge (2002) and Baltagi-Li (1991). According to the latter tests, the null hypothesis of no first order serial correlation is accepted at high statistical levels of significance.

results prove that with a $T \approx 30$ then a fixed effects estimator is the best alternative with the smallest root mean square error (RMSE). The GMM estimator can more effectively correct bias in panels with smaller number of $T (< 10)$ (a characteristic more usually met in micro data sets), while if $10 < T < 20$ then an Anderson Hsiao (1981) estimator should be chosen.

Table 4.3 Benchmark Results and Diagnostic Tests: Fixed Effects Estimates from Equation (4.12)

Period	1982-2003	1982-2003	1982-2003
Coefficient	(1) FE	(2) FE	(3) FE
$\Delta \log TFP_{i,F,t}$	0.350*** (2.44)	0.342*** (2.36)	0.371 *** (2.60)
TFP_{gap}	0.07 (5.57)	0.077 (6.27)	0.0504 (3.17)
$\log(Trade / X)_{i,t-1}$	-0.041 (1.46)		
$\log(Trade / X)_{i,t-1} * TFP_{gap}$	0.0143* (1.66)		
$\log(IMP / X)_{i,t-1}$		-0.015 (0.69)	
$\log(IMP / X)_{i,t-1} * TFP_{gap}$		0.009 (1.08)	
$\log(EXP / X)_{i,t-1}$			-0.086*** (2.47)
$\log(EXP / X)_{i,t-1} * TFP_{gap}$			0.189*** (2.44)
Observations	276	276	276
Diagnostic Tests			
R-squared	0.35	0.34	0.36
Modified Wald Test	240.06	262.15	279.28
for Heteroscedasticity, chi2(17)	(0.000)	(0.000)	(0.000)
Pesaran Test	8.460	8.904	7.815
for Cross-sectional Dependence	(0.000)	(0.000)	(0.000)
Wooldridge Test	0.006	0.001	0.020
for Serial Correlation, F(1, 11)	(0.9408)	(0.9798)	(0.8898)
Baltagi-Li Test	LM(rho=0)=0.06 (0.8121)	LM(rho=0)=0.00 (0.9548)	LM(rho=0)= 0.01 (0.9416)

Notes:

Absolute t-statistics are shown in parentheses. The asterisks correspondence is *significance at 10%; **significance at 5%; ***significance at 1%. The null hypothesis of the Modified Wald test is $H_0 : \sigma_i^2 = \sigma$. The null hypothesis of the Pesaran test is $H_0 : E(e_{i,t}e_{k,t}) = \sigma_{i,k}$. The null hypothesis of the Wooldridge test is no serial correlation after allowing for an AR(1) process of the residuals. Under the null, the parameter of the lagged residual rho is equal to 0.5. The Baltagi-Li test is an LM test for first order serial correlation implemented after specifying a model of random effects. The null hypothesis is that the rho parameter of the AR(1) process of the residuals is equal to zero. The implementation of the Pesaran cross-sectional dependence test and the Baltagi-Li test are only available with balanced panels, so observations are dropped when they do not have full series across years

The estimator used to correct for group wise heteroscedasticity and cross-sectional correlation is the Feasible Generalized Least Squared (FGLS).⁷⁹ Since industries are quite different in size, each

⁷⁹ The software package used to estimate regressions throughout the chapter is STATA 9. The specific command used to fit an FGLS model in STATA is `xtgls`. Beck and Katz (1995) develop an alternative estimator that corrects for panel heteroscedasticity and cross-sectional correlation. The estimator of Beck and

observation is weighted by the industry's share in total manufacturing value added in the first year of the sample, as suggested by Redding et al. (2005). The implementation of the FGLS estimator is only available with balanced panels hence those industries without a full series of variables across years are dropped. After this data modification the new dimensionality of the panel is 22 years and 12 industries.

Results from the FGLS estimator are reported in Table (4.4), the first three columns of this table replicate specifications of Table (4.3) using an FGLS estimator. In column (1), the dependent variable is regressed on the contemporaneous TFP growth in German manufacturing industry i , the TFP distance (i.e. $TFPgap = \log(\frac{A_{i,F,t-1}}{A_{i,G,t-1}})$) between Greece and Germany at year $t-1$ in industry i , a trade variable and an interacted term of trade with TFP gap.

Katz (1995) carries many similarities with the FGLS currently used and results are not affected much from the estimation method selected.

Table 4.4 Sources of TFP Growth-Basic Results: FGLS Estimates from Equation (4.12)

Period	1981-2003	1981-2003	1981-2003	1981-2003	1982-2003
Coefficient	(1)	(2)	(3)	(4)	(5)
FGLS	FGLS	FGLS	FGLS	FGLS	FGLS
$\Delta \log TFP_{i,F,t}$	0.265 *** (3.45)	0.267 *** (3.24)	0.257 *** (3.56)	0.290 *** (3.91)	0.313 *** (4.62)
$TFPgap$	0.097 (10.9)	0.096 (9.46)	0.112 (9.87)	0.210 (3.06)	0.037 (3.82)
$\log(Trade / X)_{i,t-1}$	-0.071 *** (7.07)				
$\log(Trade / X)_{i,t-1} * TFPgap$	0.027 *** (4.96)				
$\log(IMP / X)_{i,t-1}$		-0.045 *** (4.86)			
$\log(IMP / X)_{i,t-1} * TFPgap$		0.016 *** (3.56)			
$\log(EXP / X)_{i,t-1}$			-0.049 *** (6.54)		
$\log(EXP / X)_{i,t-1} * TFPgap$			0.016 *** (4.52)		
$\log(R \& D / VA)_{i,t-1}$					0.023 *** (6.62)
$\log(R \& D / VA)_{i,t-1} * TFPgap$					-0.009 *** (6.23)
$\log(HCshare)_{i,t-1}$				-0.074 * (1.68)	
$HCshare_i * TFPgap$				0.043 * (1.94)	
Observations	276	276	276	276	252
Number of sectors	12	12	12	12	12
Number of years	23	23	23	23	22
Wald Test, Chi(4)	161 (0.00)	145 (0.00)	172 (0.00)	168 (0.00)	328 (0.00)
LL test	375.3746	366.8694	376.2834	364.373	365.7395

Notes:

Absolute t-statistics are shown in parentheses. The asterisks correspondence is *significance at 10%; **significance at 5%; ***significance at 1%. All observations are weighted by the industry's value added share in total manufacturing at the first year of the sample available. Estimates are based on a Feasible Generalized Least Squared method that corrects for heteroscedasticity and cross-sectional correlation of the residuals. The R&D series starts from 1981 hence the sample period of estimation starts from 1982 given that the variable of R&D share enters the model lagged by one year

The positive and statistically significant coefficient of the technological gap variable indicates that the more an industry lies behind the frontier, the faster is the rate of Total Factor Productivity growth. The contemporaneous term of the TFP growth in the frontier economy has a positive and statistically significant sign throughout all the specifications of the table. Regarding trade variable, the revealed pattern is very interesting. The level variable carries a negative and statistically significant coefficient, while the interacted term of trade with the TFPgap suggests that trade plays

an important role on technology transfer. The sign of the trade variables is different from each other and remains as such even if the trade variable is decomposed into exports and imports. Column (4) examines the influence of human capital ($\log HCshare_{t-1}$) and its interacted term ($HCshare_{t-1}TFPgap$). Human capital is measured by the share of workers (in total labour force) with a degree from tertiary education. Results from this specification reveal the same pattern with specifications (1)-(3). This means that as the level of human capital interacts with the productivity gap the speed of catch-up increases.

Column (5) controls for the impact of R&D on the growth of Total Factor Productivity. The level term of R&D share appears with a positive coefficient while the interacted term is negative. The results emerged suggest that the dominant impact of R&D is on the rates of innovation and not on the level of absorptive capacity. In other words, industries with a higher share of R&D expenditures tend to grow faster but this characteristic does not improve their ability to imitate more effectively the technological advancements of the “technological frontier” country. In these benchmark specifications, except for R&D the remaining variables have only an indirect effect on productivity growth. In the forthcoming analysis, a number of additional specifications will test the robustness of this pattern.

Table (4.5) presents results from a specification in which trade and R&D variables along with their associated terms are included in the same specifications. After including the whole set of productivity growth drivers, the findings do not differ substantially from what we obtain in Table (4.4). The autonomous technology transfer as measured by the relative TFP variable is positive and statistically significant at high confidence levels, confirming once again that a country, which falls far behind the frontier, tends to grow faster. The level term of trade has still a negative sign while its interacted term with the TFP gap is positive. The R&D level continues to be positive as Table (4.4) shows and the R&D interacted term remains negative. There is only a minor difference in the sign of the level term of human capital, which is now positive and thus consistent with the economic

priors, but this is likely to reflect only a marginal change since the estimated coefficient is not statistically different from zero.

In column (2), the variable of interest is the minimum to median wage representing the role of labour market conditions on TFP growth. As discussed earlier, a stringent labour market can be a serious obstacle for productivity upgrading from a number of different aspects. But, the definition of the present variable allows us to assess only the impact of labour cost adjustments on productivity growth. On that basis, Table (4.5) confirms the negative role of labour market rigidities, as the ratio of minimum to median wage has a negative coefficient with an absolute t-value equals to 2.06.

Column (3) presents results from a specification that includes a measure of domestic market concentration. Note that data for this variable are only available from 1993 and onwards, thus the length of the panel is reduced by twelve years. The estimated coefficient of domestic concentration is positive (t-value is 3.87) supporting the argument that industries with high degree of concentration operate in a higher scale of production increasing the overall productivity. Estimating equation (4.12) for the reduced sample causes a radical difference in the estimated coefficient of the R&D share. The latter is now negative with a statistically significant coefficient. We attribute the change in the sign to the slow process that characterises the potential outcomes of the R&D activity. In a panel with a relatively long time series, as in columns (1) and (2) of Table (4.5), there is enough time to implement the R&D effort into productivity gains. Within a shorter time horizon, R&D activity entails costs without ensuring a direct successful research outcome.

Table 4.5 Sources of TFP Growth-Further Specifications: FGLS Estimates from Equation (4.12)

Period	1982-2003	1982-2003	1994-2003
Coefficient	(1) FGLS	(2) FGLS	(3) FGLS
$\Delta \log TFP_{i,F,t}$	0.277*** (5.38)	0.280*** (4.76)	0.189*** (3.36)
$\log TFP_{gap}$	0.186 (3.14)	0.150 (2.45)	0.334 (2.67)
$\log(Trade / X)_{i,t-1}$	-0.114*** (10.6)	-0.107*** (9.17)	-0.197*** (9.83)
$\log(Trade / X)_{i,t-1} * TFP_{gap}$	0.039*** (6.27)	0.036*** (5.46)	0.058*** (7.20)
$\log(R \& D / VA)_{i,t-1}$	0.038*** (11.8)	0.035*** (10.2)	-0.05*** (6.98)
$\log(R \& D / VA)_{i,t-1} * TFP_{gap}$	-0.015*** (10.3)	-0.014*** (8.64)	-0.039*** (0.62)
$\log(HCshare)_{t-1}$	0.031 (0.86)	0.062 (1.38)	0.144*** (2.71)
$\log(HCshare)_t * TFP_{gap}$	0.04** (2.02)	0.032 (1.59)	0.058*** (7.20)
$\log\left(\frac{MinWage}{MedianWage}\right)_{t-1}$		-0.082** (2.06)	-0.064 (1.39)
$\log CR_{i,t-1}$			0.021*** (3.87)
Observations	264	264	120
Industry Fixed Effects	Yes	Yes	Yes
Number of sectors	12	12	12
Number of years	22	22	10
Wald Test/F Test	Chi(8)=697 (0.00)	Chi(9)=519 (0.00)	Chi2(10)=469 (0.00)
Log-likelihood	380.8224	381.7314	581.6265

Notes:

Absolute t-statistics are shown in parentheses. The asterisks correspondence is *significance at 10%; **significance at 5%; ***significance at 1%. All observations are weighted by the industry's value added share in total manufacturing at the first year of the sample available. Estimates are based on a Feasible Generalized Least Squared method that corrects for heteroscedasticity and cross-sectional correlation of the residuals

4.5.1 Results from Benchmark and Further Specifications-Comparison with Other Studies

The results shown in Tables (4.4) and (4.5) suggest that autonomous technological transfer plays an important role on the movements of TFP growth. Precisely, the coefficient of the autonomous transfer variable is 15% in column (2) of Table (4.5). This magnitude suggests that each year a typical Greek manufacturing industry covers 15% percent of the productivity gap that has with its German counterpart. From this figure, the solution of the steady-state equilibrium condition (4.5) implies that the autonomous technology transfer takes 3.3 years to close half of the gap in technical efficiency between the Greek and the German industry.

Appendix C4.3 provides a formal unit root test for stationarity testing whether the model specified in (4.10) is a good approximation of an equilibrium correction model (ECM). The coefficient of autonomous technological transfer of the present study indicates that the catch up process in Greek industries is rapid. A similar speed of adjustment is found in Redding et al. (2005) in which the estimated coefficient of technology transfer between UK and US is 14%. Nonetheless, other studies reveal different speed of technological convergence across countries. For example, Cameron (2005), after using a specification very similar to this one of Table (4.5), finds that the speed of adjustment in Japanese industries towards their US counterparts is 6.3%, while, Khan (2006) reveals a speed of adjustment of French industries towards US counterparts in the order of 6.5%.

Prescott (1997) suggests that TFP growth reflects changes in organizational practices occurred at the firm or at the industry level. From this point of view, institutional reforms can accelerate the process of productivity convergence. Given that the present study does not address explicitly the impact of institutional factors on TFP growth, the relatively high speed of catch-up in the present study is likely to reflect successful organisational and institutional reforms that allow

Greek manufacturers to adopt more quickly and effectively the technological developments of the frontier country.

Among the important drivers of TFP growth is the interacted term of trade with TFPgap. This finding indicates that as industries are open to trade openness then they can implement faster the technological techniques initially developed in the frontier economy. Evidence from trade-based technological transfer is consistent with both industry (Redding et al. (2005)) and country level studies (Prescott and Parente (1991)) that assess through which channels the speed of technology diffusion is faster. According to the present results, the absorptive capacity of Greek manufacturing industries is improved only through trade and not through R&D activity. The interacted term of R&D with TFP gap is negative throughout all the specifications in Table (4.5) implying that the second face of R&D as suggested by Griffith et al. (2004) is not present in the case of Greece. In contrast, R&D maintains its important role on stimulating productivity growth through innovation. The latter result confirms the well-established impact of innovation on output growth documented mainly in firm level studies (Griliches (1970) and Griliches and Regev (1995)).

The present study reveals a multifaceted role for human capital. The number of workers with at least a degree from tertiary education as a share of total number of workers proved to have a positive influence on TFP growth. Additionally, a higher level of human capital allows for some externalities since the interacted term of human capital with the variable of TFP gap is always a positive determinant of TFP growth. In the present study, human-based and trade-based technological transfer are the two main channels through which a fast and effective implementation of foreign technology takes place.

Finally, distortions in labour markets have a negative impact on TFP growth. The variable used is the ratio of minimum to median wage, which reflects the bargaining power of the trade unions and the effects of welfare state. The scenario confirmed is that collective wage agreements determine an actual wage that is far above the competitive level of the marginal product of labour. This is a clear signal about the power of trade unions and also indicates the negative effects of the

welfare state on productivity growth. The presence of welfare state through the imposition of minimum wage and the over-protection of labour market increases the adjustment costs of labour inputs and harms entrepreneurship. Firms that wish to achieve a high level of dynamic efficiency they need to recruit personnel from the external market. The high reservation wage due to the minimum wage policy is a crucial disincentive for any firm seeks to follow this strategy. The alternative is to retrain the existing personnel in order to acquire the skills for the new technological standards. This choice is not as simple as it seems since wages are already above the competitive level, the training of personnel causes an additional burden to labour costs weakening the ability of firms to follow the new technological developments (Scarpetta et al. (2006)).

4.6 Sensitivity Analysis

4.6.1 Non-Linearities in the TFP Growth–Trade Relationship and the Bounded Nature of Trade

Several issues remain unanswered regarding the analysis presented in the previous section. Some results obtained above contradict the theoretical expectations and therefore some further analysis is required to check whether the findings of the previous section yield a particular structural pattern or simply reflect a problem in the definition of specific variables. The present section conducts some sensitivity tests seeking to test for the robustness of the results presented in Table (4.5).

Table (4.5) does not reveal any positive impact of trade on TFP growth. This finding is not in accordance with the propositions of the endogenous growth theory and it also diverges from findings of other empirical studies. However, notice that the trade variable used here refers to the industry's total trade and it is not restricted to trade with Germany (the technological frontier country) or with any other groups of countries. The lack of positive evidence for the impact of trade on productivity growth calls for further investigation into the trade-induced growth process.

The first scenario examined is based on the idea that learning-by-exporting is a similar concept to learning-by-doing. This implies that learning-by-exporting might be described more accurately by a non-linear relationship. Going back to the seminal work of Arrow (1962), the key point suggested is that learning-by-doing is an accumulated product of experience and as such, it is subject to diminishing returns to scale. Accepting that dynamic gains from exporting exist but they are non infinite implies that after a critical threshold further an increase of export activity is unable to generate significant benefits.⁸⁰

The second alternative scenario examined, is motivated by the models of Young (1991) and Chuang (1998), which emphasize the bounded nature of learning induced by trade. The key

⁸⁰ Similarly, the argument can be at work from the reverse side, exposure in international markets does not ensure automatically learning benefits. Instead, exporters need to reach a crucial threshold after which they can start experiencing substantial knowledge gains from exporting.

development of these models is that learning-by-trading is critically determined by the pattern of trade (i.e. the types of goods traded) and the identity of the trading partner.

Table C4.4 in Appendix C replicates specification of column (2) in Table (4.5) after controlling for a non-linear relationship between trade and TFP growth as well as for a bounded nature of trade. Specification (1) presents results from a quadratic term of both trade share and the interacted term. The negative sign of the trade share is not eliminated while the interacted term now appears with a negative impact. However, these estimates cannot be viewed as informative since coefficients are not statistically significant.⁸¹ Specifications (2) to (3) refer to estimates when trade with G7 countries is only considered. The ratio used is the sum of imports (exports) to G7 over the total amount of imports (exports). The rationale of this specification is based on the idea that these countries are clearly more technologically advanced than Greece and thus increases in trade involvement of Greek industries with them can facilitate significant knowledge spillovers.

The only robust effect from these specifications is that import-based technological transfer is important for productivity growth when imports from the G7 countries are considered. The technological content of these imports is usually high fostering Greece's absorptive capacity and thus accelerating productivity growth. Overall, evidence of Table (C4.4) in Appendix C cannot support neither a non-linear relationship between trade and productivity growth nor a bounded nature of trade.

4.6.2 TFP Growth and Alternative Measures of R&D

A further check of robustness involves the measurement of R&D. The previous section relies on a flow measure of R&D. However, it seems reasonable to assume that knowledge is an accumulated process rather than a one – off effect. Therefore, R&D is also measured as a stock variable obtained by the standard perpetual inventory equation:

⁸¹ Results (not shown) here from quadratic terms of imports and exports are very similar to the specifications displayed in Appendix C4.4.

$$RDstock_{i,t} = (1 - \delta)RDstock_{i,t-1} + RDexpenditure_{i,t}$$

Here, $RDstock_{i,t-1}$ describes the accumulated stock up to period $t-1$ and $RDexpenditure_{i,t}$ denotes industry i 's R&D expenditure conducted at year t . The initial R&D stock in industry i is calculated using a benchmark equation, which is identical to the formula of initial physical capital stock applied previously. A standard dilemma encountered in the calculation of the above equation is a plausible assumption about the depreciation of the R&D stock. The present measure assumes a rate of 5%, admittedly this assumption seems arbitrary; although, it makes no difference to the qualitative picture of the econometric results if it is assumed a rate of 10 or 2.5%.

The econometric results of the previous section reveal that R&D share has a positive impact on TFP growth. Nevertheless, R&D activity does not contribute to improvements in Greece's absorptive capacity. Griffith et al. (2004) note that countries lying far behind the frontier initially conduct little R&D and thus the marginal productivity of R&D at the early stages is quite high. Although, this argument cannot explain why the interacted term of R&D in the main econometric results is negative implies clearly that R&D activity might be subject to a non-linear process.⁸²

Table C4.5 in Appendix C replicates specifications (2) and (4) of Table (4.5) checking for a non-linear relationship between R&D and TFP growth. In the same table, a stock measure of R&D is used to provide a means of comparison with the results obtained from the measure of R&D flow. Estimates from R&D stock and R&D flow are almost identical. The level variable of R&D remains positive and significant confirming the crucial role of innovation as a conduit of TFP growth while the interacted term of R&D stock is negative. A radical change occurs in columns (2) when we control for the quadratic term of R&D share. This negative pattern suggests the existence of decreasing returns to R&D expenditure. Given that the liner term of R&D is positive, the negative sign of the quadratic term implies that the marginal productivity of R&D decreases as R&D expenditure increases. In such a pattern, industry absorptive capacity is a positive function of R&D.

⁸² If this argument holds, then a not R&D intensive country like Greece should have a high marginal productivity of R&D at the early stages. On this basis, the interacted R&D term should have been positive.

The message emerged from column (2) in the Table C4.5 is that even if R&D activity, after a certain point, becomes of no importance in affecting productivity growth, it improves the industry's ability to assimilate and exploit existing information or technological achievements developed externally.

4.6.3 TFP Growth with a Different Frontier Country

The last test of robustness refers to the definition of the “frontier” country. The econometric results so far explore the sources of TFP growth considering Germany as the “technological frontier” country. However, one can pose the crucial question whether the existing results are sensitive to a different definition of the “technological frontier”. To address this issue, specifications (2)-(5) of Table (4.5) are re-estimated using the French manufacturing sector as the “technological frontier”.

There are not substantial differences after considering France as the “technological frontier” country (Table C4.6 in Appendix C). The main forces driving TFP growth in Greek manufacturing industries have the same signs as in Table (4.5). There are only minor changes in the statistical significance of the variables. The main message emerged after using France as the “technological frontier” country is that trade-based technological transfer and R&D activity remain as the most principal sources of productivity growth (i.e. the interacted term of trade is positive and statistical significant). Similarly, the variable that represents the labour market conditions has a negative sign confirming once again the negative impact of labour market distortions on TFP growth.

4.7 Conclusions

It is widely acceptable that the economic welfare of a country is strongly associated with its productivity records. Sharpe (2002b) demonstrates that most of the mainstream indices used to measure economic well-being are implicitly or explicitly determined by productivity gains. The propositions of the endogenous growth theory suggest that productivity growth is driven by

investment in innovation, human capital and trade openness. The present chapter assesses the contribution of these factors to productivity growth of Greek manufacturing industries under the general theme of productivity convergence. This framework stresses the potential of technological transfer between a frontier and a non-frontier economy.

Germany is chosen as the “frontier” country and the empirical evidence suggests that technology transfer is of special importance for a “non-frontier” country like Greece. The intra-European character of the present empirical study is associated with a central issue of the European economic integration agenda. To narrow the gap between the core and the peripheral countries of EU, we need to accelerate the pace of technological transfer. As peripheral countries do not have enough resources to stimulate rapid rates of growth, imitation from the advanced countries of EU is the key conduit for sustainable growth.

Although the results obtained in the present study refer exclusively to Greek manufacturing industries, a number of general lessons can be drawn with regard to other European countries, especially for those with similar economic features with Greece. The first finding of the study is that there is a convergence process at work during the sample period, which occurs at a rapid rate. The speed of catch-up process between Greek and German industries is higher than the speed of convergence documented on other pair of countries in the literature. This finding along with the result that the autonomous technological transfer is an important contributor to TFP growth confirm the argument of the traditional convergence literature that countries fall behind tend to grow faster.

The chapter also explores whether trade, R&D and human capital have an indirect impact on TFP growth. Recent literature proves that R&D has a dual role, the first is to promote innovation and the second is to improve absorptive capacity. The first role highlights the private rate of return to R&D expenditure while the latter indicates the social aspect of R&D. The social return to R&D implies that research activity might not be effective in producing a new product but improves the ability of an industry to imitate effectively the existing technological information. Similarly, trade and human capital may have both direct and indirect effects on growth. The present study does not

find evidence for the second role of R&D, instead it confirms that R&D promotes innovation, which is a principal channel of productivity growth. Although, the statistical magnitude of the above result is robust, the nature of R&D activity maintains many unexplored characteristics. For example, the sensitivity analysis reveals that R&D effort is subject to diminishing returns, thus gains from R&D research are realized up to a certain threshold. Beyond this, R&D does not promote innovation, instead improves the industry's absorptive capacity. Therefore, further research should be undertaken to provide more overwhelming evidence for the precise relationship between R&D and growth. On this basis, a more systematic framework is required to reveal which are the factors that drive industries to invest in R&D.

The chapter provides clear and robust evidence for trade-based technological transfer. The interacted term of trade with the productivity gap variable is significant and positive throughout different specifications which shows that trade exposure helps Greek industries to close faster the gap with their German counterparts. The preliminary specifications of the chapter reveal that both importing and exporting are important engines of technology transfer. Results reveal consistently a negative coefficient of trade share opposing the propositions of the endogenous growth theory. A sensitivity analysis does not support the hypothesis that the relationship between trade and productivity is non-linear as well as it does not confirm the proposition that the identity of trading partners matter. This set of empirical findings tends to support that trade induced gains are indirect and occur mainly through accelerating the rate at which the productivity convergence occurs.

Two new variables are also added to the analysis to reflect the impact of domestic market conditions on TFP growth. The ratio of minimum wage to median wage is consistently negative and in almost all the specifications is significant. Concerning the concentration index, results are compatible to the view that monopolistic power in the market is not an obstacle for efficiency since the dominant firms can exploit economies of scale and hence industry productivity growth can be positively affected.

From a policy-making standpoint, results regarding the variable of labour market rigidities can provide interesting insights. Before stating strong conclusions, one might think that the variable currently used describes only some distortions of the labour market. There are also other variables that can provide information about the distortions of labour market from a different point of view. For instance, measures that refer to the number of missing hours due to strikes can also reflect the power of trade unions. Although, one can easily find data for the number of strikes for the aggregate economy is rather difficult to find this piece of information for disaggregate manufacturing industries. Similarly, to the best of our knowledge there is no data for the Greek manufacturing sector regarding the share of workers that covered by a collective wage agreement or any information that represents the share of trade union workers.

As already discussed, the negative impacts of labour market distortions on TFP growth are resulted in by the power of trade unions and the role of welfare state. The latter harm entrepreneurship as they prevent firms from adjusting their labour force effectively and quickly. As a result, firms find difficult to follow technological opportunities and remain inefficient for a long period of time. After all, the crucial question posed is what type of policy reforms within the labour market will have a positive impact on productivity growth? An insightful discussion of this issue is beyond the scope of this chapter but less state intervention in labour markets will certainly benefit TFP growth as already suggested by Scarpetta and Tressel (2002). Another contribution towards a more flexible labour market will be to ensure that the salary schemes agreed under the national bargaining agreement reflect the levels of labour productivity.

Some issues though remain unexplored and definitely need further investigation. Two paths for further research that are strongly related to the current work are to quantify the direct impact of foreign R&D on domestic TFP (Coe and Helpman (1995) and Kneller (2000)) and to assess to what extent the pattern of trade (i.e. type of goods traded) matters for TFP growth. In addition, future research should address the issue whether FDI and firm dynamics have an impact on TFP growth. The presence of multinational companies in the domestic market is a channel that can diffuse new

effective techniques and ideas boosting the rate of TFP growth. Simultaneously, entries (exits) in (from) the market as well as factors that drive this type of movements constitute crucial issues of the productivity research agenda (Scarpetta et al. (1999)).

Appendix C

Appendix C4.1

Total Factor Productivity

The main source of data used in calculating TFP is OECD-STAN. Variables used are Value Added (VALU), Value Added Volume (VALUK), Labour Compensation of Employees (LABR), Employees (EMPE), Gross Fixed Capital Formation (GFCF), Gross Fixed Capital Formation Volume (GFCFK). Full data series for Greek industries are available only for the period 1995-2003. Prior to this period, STAN reports data only for value added and labour compensation. Data for the remaining variables for the period 1980-1994 are taken from EU KLEMS project conducted by Groningen Growth and Development Centre (GGDC). Data for hours worked in each manufacturing sector are taken from GGDC 60-Industry database. OECD-STAN provides a full data series for Germany during the whole period, for years before 1990 data refer to West Germany. Missing values in GFCF and GFCFK for German industries for 2003 are filled with values taken from EU KLEMS- GGDC database.

Trade

Values of imports and exports for Greek manufacturing industries for the period 1995-2003 are provided by OECD-STAN (release 05), while data for the period 1980-1994 are taken by OECD-STAN (release 01). Trade share is the sum of imports and exports over production in nominal values. Trade data are not deflated into real values due to lack of appropriate deflators.

Research and Development

Data for R&D expenditures are taken from OECD in current PPP-USD (Main Science and Technology Indicators, releases: 13r2-13r3). This data series starts from 1981 and has many missing values within year intervals. The missing data are filled in using a standard interpolation routine. The nominal R&D values are deflated by an R&D price index, which is defined as: $PR = 0.5(VAI + WAI)$, where VAI is a value added industry specific deflator and WAI is a

nominal manufacturing wage index, taken from the International labour Organization (ILO). Coe and Helpman (1995) use the above R&D deflator considering that half of the R&D expenditures are labour costs.

Human Capital

Human capital is measured as the share of workers with tertiary education over the entire labour force. Data for educational enrolment by level are taken from UNESCO.

Concentration Ratio

An ideal measure for the degree of concentration is the Herfindahl-Hirschman index. However, this calculation requires specific information for the whole number of individual firms in each industry and such a disaggregate data set is not available in the present study. Following a methodology proposed by Schmalensee (1977), the concentration index is computed as:

$$CR = \frac{(AS_1 - AS_2)^2 (n_1^2 - 1)}{3n_1} + h; \quad h = n_1 (AS_1)^2 + (n - n_1)(AS_2)^2$$

where AS_1 and AS_2 are the average market shares of the five largest firms and the remaining firms of the industry, respectively. Using n and n_1 to denote the total firm population and the group of the largest firms in the industry (i.e. in the current case this is five) the above index is easily computable. Schmalensee (1977) considers Herfindahl-Hirschman index as the ideal measure and after comparing twelve possible surrogates concludes that, the above index is the second best alternative. The market share of the top five firms in each industry is calculated using information of total assets in nominal values as provided by ICAP. The latter is a private Business Information and Consulting company that reports financial data for Greek manufacturing firms. Data used in the present study are reported in the annual financial directory of the Greek manufacturing sector and are only available from 1993 to 2003.

Table C4.2 Summary Statistics of Variables

Variable	Observations	Mean	Std. Dev.	Min	Max
<i>Trade / X</i>	276	0.766	0.888	0.105	6.383
<i>Imp / X</i>	276	0.529	1.069	0.029	5.796
<i>Exp / X</i>	276	0.167	0.796	0.018	0.690
<i>HC</i>	276	0.064	0.387	0.033	0.122
<i>R & D / VA</i>	276	0.047	0.102	0.000	0.735
<i>CR</i>	132	0.346	0.251	0.070	0.999

Notes:

Trade / X =Imports plus Exports to output, *Imp / X* = Imports to output, *Exp / X* =Exports to output,
R & D / VA =R&D to value added, *HC*= Share of workers (from total labour force) with a degree from
tertiary Education, *CR*=Concentration ratio of the top five firms in the industry

Appendix C4.3

To obtain a more formal test of convergence for each industry the methodology of Bernard and Durlauf (1995) and Bernard and Jones (1996a) is followed. In the present framework a Greek industry i is said to converge towards its German counterpart i if the TFP gap (i.e. $TFPgap = \ln(A_{i,F,t}) - \ln(A_{i,G,t})$, $i=1,...,N$) variable is stationary. A test of stationarity is developed by Kwiatkowski et al.(1992) or KPSS for brevity. This test differs from the standard Dickey-Fuller and Perron unit root tests by having a direct null hypothesis of stationarity. The null hypothesis of the KPSS test is implemented for both trend and level stationarity. As shown in both columns of the table below, the null hypothesis of stationarity is accepted in all industries. Equivalently, this suggests that convergence is at work for all industries in the sample. The acceptance of the null hypothesis implies that the model specified in (4.10) is a close approximation of an equilibrium correction model (ECM). The economic intuition of the equilibrium correction model in a framework of productivity convergence is that with not stationarity in the TFP gap variable, the long-run average productivity growth would be different (Bernard and Jones (1996a)).

Table C4.3 Unit Root Tests

Industry	Trend	Level
Food Products, Beverages and Tobacco	0.154	0.391
Textiles, Textile Products, Leather and Footwear	0.157	0.391
Wood and Products of Wood and Cork	0.148	0.394
Pulp, Paper, Paper Products, Printing and Publishing	0.143	0.395
Coke, Refined Petroleum Products and Nuclear Fuel	0.143	0.391
Chemicals and Chemical Products	0.15	0.386
Rubber and Plastics Products	0.148	0.392
Other nonmetallic Mineral Products	0.136	0.419
Basic Metals	0.148	0.402
Fabricated Metal Products, Except Machinery and Equipment	0.139	0.379
Machinery and Equipment, nec.	0.145	0.369
Electrical Machinery and Apparatus, nec	0.157	0.387
Radio, Television and Communication Equipment	0.15	0.4
Medical, Precision and Optical Instruments, Watches and Clocks	0.144	0.154
Other Transport Equipment	0.2	0.395
Manufacturing nec	0.158	0.396

Notes:

The null Hypothesis in both columns is that TFP gap is stationary or equivalently that each industry converges. Critical Values are taken by KPSS (1992) and for trend stationarity are: 2.5%:0.176; 1%:0.216. Critical Values for Level stationarity are: 2.5%:0.574; 1%:0.739. The maximum lag order of the test is derived from a rule provided by Schwert (1989). The Schwert criterion for the current test chooses 8 as maximum lags for all industries.

Table C4.4 Sources of TFP Growth-Non-Linear Trade and Trade with G7: FGLS Estimates from Equation (4.12)

Period	1982-2003	1982-2003	1982-2003
Coefficient	(1)	(2)	(3)
	FGLS	FGLS	FGLS
$\Delta \log TFP_{i,F,t}$	0.248***	0.223***	0.214***
	(3.61)	(2.93)	(2.75)
$\log TFPgap$	0.022	0.082	0.036
	(1.92)	(5.00)	(1.83)
$\log \left(\frac{Trade}{X} \right)_{i,t-1}^2$	-0.004		
	(0.98)		
$\log \left(\frac{Trade}{X} \right)_{i,t-1} * TFPgap$	-0.003		
	(0.89)		
$\log(R \& D / VA)_{i,t-1}$	0.019***	0.025***	0.004
	(4.82)	(5.20)	(0.66)
$\log(R \& D / VA)_{i,t-1} * TFPgap$	-0.007***	-0.008***	0.001
	(4.17)	(2.44)	(0.27)
$\log \left(\frac{MinWage}{MedianWage} \right)_{t-1}$	-0.097***	-0.145***	-0.215***
	(3.29)	(3.84)	(5.10)
$\log(IMP7 / X)_{i,t-1}$		-0.070***	
		(6.94)	
$\log(IMP7 / X)_{i,t-1} * TFPgap$		0.030***	
		(4.24)	
$\log(EXPG7 / X)_{i,t-1}$			-0.008
			(0.91)
$\log(EXPG7 / X)_{i,t-1} * TFPgap$			-0.008
			(1.19)
R-squared	0.2039	0.05	0.215
Observations	264	180	180
Number of sectors	12	12	12
Wald test	262.68	205.76	138.83
	(0.00)	(0.00)	(0.00)

Notes:

Absolute t-statistics are shown in parentheses. The asterisks correspondence is *significance at 10%; **significance at 5%; ***significance at 1%. All variables are weighted by industry's value added in manufacturing sector at the first year available. The FGLS estimator corrects for heteroscedasticity and cross-sectional correlation. The Wald test refers to the hypothesis that the estimated coefficients are jointly zero

Table C4.5 Sources of TFP Growth-Alternative Measures of R&D: FGLS Estimates from Equation (4.12)

Period Coefficient	1982-2003 (1) FGLS	1982-2003 (2) FGLS
$\Delta \log TFP_{i,F,t}$	0.264*** (3.81)	0.241*** (3.54)
$\log TFP_{gap}$	0.058 (4.98)	0.066 (6.68)
$\log(Trade / X)_{i,t-1}$	-0.089*** (7.71)	-0.085*** (7.01)
$\log(Trade / X)_{i,t-1} * TFP_{gap}$	0.032*** (4.72)	0.031*** (4.47)
$\log(R \& Dstock / VA)_{i,t-1}$	0.023*** (5.31)	
$\log(R \& Dstock / VA)_{i,t-1} * TFP_{gap}$	-0.007*** (4.98)	
$\log(R \& D / VA)^2_{i,t-1}$		-0.002*** (6.35)
$(R \& D / VA)^2_{i,t-1} * TFP_{gap}$		0.0009*** (5.49)
$\log\left(\frac{MinWage}{MedianWage}\right)_{t-1}$	-0.104*** (3.75)	-0.0596** (2.04)
R-squared		
Observations	264	264
Number of sectors	12	12
Wald Statistic	321.08 (0.00)	315.94 (0.00)

Notes:

Absolute t-statistics are shown in parentheses. The asterisks correspondence is *significance at 10%; **significance at 5%; ***significance at 1%. All variables are weighted by industry's value added in manufacturing sector at the first year available. The FGLS estimator corrects for heteroscedasticity and cross-sectional correlation. The Wald test refers to the hypothesis that the estimated coefficients are jointly zero

Table C4.6 Sources of *TFP* Growth-France is the Frontier: FGLS Estimates from Equation (4.12)

Period Coefficient	1982-2003 FGLS
$\Delta \log TFP_{i,F,t}$	0.314*** (4.58)
$\log TFP_{gap}$	0.297 (4.13)
$\log(Trade / X)_{i,t-1}$	-0.096*** (8.32)
$\log(Trade / X)_{i,t-1} * TFP_{gap}$	0.032*** (5.60)
$\log(R \& D / VA)_{i,t-1}$	0.025*** (5.47)
$\log(R \& D / VA)_{i,t-1} * TFP_{gap}$	-0.01*** (5.29)
$\log \left(\frac{MinWage}{MedianWage} \right)_{t-1}$	-0.093** (2.07)
R-squared	0.1520
Observations	242
Number of sectors	11
Wald test	328.98 (0.00)

Notes:

Absolute t-statistics are shown in parentheses. The asterisks correspondence is *significance at 10%; **significance at 5%; ***significance at 1%. All variables are weighted by industry's value added in manufacturing sector at the first year available. The FGLS estimator corrects for heteroscedasticity and cross-sectional correlation. The Wald test refers to the hypothesis that the estimated coefficients are jointly zero

Chapter 5

Conclusions

5.1 Main Findings of the Thesis

This chapter presents an overview of the main findings and discusses some general implications derived from the current thesis. The last part of the chapter provides useful recommendations for future research.

The main objective of the current thesis is to investigate a set of important aspects that are related to the broad theme of competitiveness. In economics, ‘competitiveness’ is just too broad a term, since its meaning is rooted in the management and business literature. Without a precise definition of the term “competitiveness”, one is unable to determine what improves the relative or the absolute competitiveness of economic units.

Throughout the thesis, competitiveness is used in connection with the concepts of effectiveness and productivity. With this consideration in mind, the findings of the second chapter are as follows:

Is cost effectiveness a factor that determines Greek Manufacturing exports?

There are two scenarios that link cost effectiveness to export performance. The first scenario indicates that efficiency gains can assure the resources needed in order to expand commercial activities in foreign markets, while the second scenario indicates that *x*-efficiency improvements can partially “pass-through” to prices improving price competitiveness of Greek products in international markets.

The evidence emerged from Chapter 2 supports the above hypothesis since the measure used to approximate cost effectiveness proved to be one of the most important determinants of export performance. The latter is also affected by domestic demand conditions. The intuitive interpretation of this finding is that Greek manufacturers view export activity as a residual activity and hence, if

the domestic market experiences an expansion, this acts as a disincentive for substantial export involvement.

For many economists competitiveness is synonym to productivity. One of the first topics taught to undergraduate economic students is that countries have to make decisions under some restrictions. In other words, as economic agents, we make decisions that maximise our welfare subject to a set of constraints. At the national level, this consideration implies that countries specialise in the production of those goods that they have a comparative advantage. In this respect, the term “national competitiveness” becomes equivalent to the idea of comparative advantage and thus the crucial question that emerges,

What forces determine the nature of comparative advantage and the pattern of specialisation?

The analysis of this issue is implemented within the propositions of the neoclassical model. Precisely, Chapter 3 evaluates to what extent H-O and Ricardian theorems can provide plausible answers for the pattern of specialisation. An innovative element used in the analysis of Chapter 3 is to estimate a joint model in which both the contributions of H-O and Ricardo are taken into account. This model provides clear results regarding the pattern of specialisation, as long as national factor supplies do not drive factor intensity at the industry level. The investigation of the pattern of specialisation becomes complicated if, for instance, the national capital abundance makes productivity to be consistently higher at the industry level. As far as the present sample of countries is concerned, we conclude that the national factor endowments are not associated with actual factor intensity, implying that H-O and Ricardian forces have their own contribution to the pattern of specialisation. Findings from estimating the joint model reveal that the output share of capital intensive industries such as coke, electrical transport and chemicals is positively affected by changes in national capital abundance. A similar finding is documented for energy intensive industries, and national energy abundance. An industry's productivity is a positive determinant of

specialisation mainly for low and middle technology industries. An interesting lesson from the estimates of Chapter 3 is that skill intensity is a source of disadvantage in manufacturing industries. Overall, the general lesson learned from the analysis in Chapter 3 is that H-O theory is in accordance with the data used in the thesis.

The main goal of Chapter 4 is to investigate through which mechanisms TFP growth is accelerated. This empirical exercise is of particular interest if one takes into consideration that productivity matters both for export performance and, more generally, for the pattern of specialisation. The core question in Chapter 4 is specified as follows:

What are the forces of Total Factor Productivity (TFP) Growth?

The implementation of the research exercise is conducted with data from the Greek manufacturing sector. For a non-frontier country like Greece, it is of particular importance to investigate the sources of productivity growth within a framework of productivity convergence. Adopting this methodology allows us to assess to what extent technology transfer from a “technological frontier” economy serves as a channel of productivity growth. The two most important findings of Chapter 4 are that technology transfer is a principal source of productivity growth, as well as that the rate of technology transfer is accelerated as industries become more open to trade.

5.2 General Policy Implications

The evidence gathered via the research carried out in the present thesis has a number of important implications for both Greek policy makers and for trade theorists. Specific policy implications have been pointed out in the conclusive sections of each individual chapter. In this part, we highlight some general policy implications that derive from the general theme of the thesis,

which is competitiveness. After one specifies what are the key aspects of competitiveness, a natural question that emerges is:

What does improve national competitiveness?

According to the main conceptual framework of this thesis, the answer to this question is equivalent to asking what improves productivity. Although, the term “competitiveness” is not properly defined at the national level, various policy strategies can be employed to improve competitiveness of micro-units (firms or industries) and thus improving implicitly national competitiveness. To the extent that productivity depends on industry-specific characteristics such as ownership structure or (and) organisational skills, the margin for state intervention is very limited. To the extent that economy wide events can affect an industry’s productivity, governmental policies can play a crucial role. As shown in Chapter 4, technology transfer is the most important driver of productivity growth. The speed and the adoption of foreign technology are determined to some degree from the economic environment of the non-frontier country. In brief, five policy suggestions are provided to ensure that the wider economic environment does not impede the mechanisms that stimulate higher rates of productivity growth:

1. Reduction of transaction costs that emerge from economic activity. From a more general point of view, upgrading the operation of the public service, bureaucratic phenomena can be eliminated allowing firms to transact with public authorities in a fast and effective way.
2. Provision of consulting services regarding the existence of appropriate domestic and foreign markets with good potential.

3. Easy access to financial markets in order to obtain financial assets needed to expand commercial activities. Operating at a higher scale of production allows the exploitation of scale economies.
4. No radical and sudden changes in the taxation system as this may harm entrepreneurship.
5. Provision of subsidies that promote mainly the development of new innovation projects. Policy makers should be very careful when using subsidies, as an erroneous use of the subsidiary policy tool is likely to make the whole society worse off by diminishing residents' economic welfare.

5.3 Paths for Future Research

We want to believe that the present thesis has addressed a number of crucial issues, providing important insights mainly about trade, specialisation and productivity, yet, there are matters that they are questionable and can be used as points of departure for future research.

Chapter 2 evaluates whether an index of productivity is a positive determinant of export performance. It is widely known that in the productivity–exporting nexus, there is a crucial issue of causality. Subject to some necessary conditions, such as the existence of panel data set with long time spans, the issue of causality can be formally addressed to reveal whether exports (productivity) Granger-cause productivity (exports).

In Chapter 2, the measure of cost effectiveness only partially represents price competitiveness. If one wants to obtain more direct results about the impact of relative prices on exports then the use of a partial equilibrium model, as suggested by Reenen et al. (2001), would be the preferred strategy.

The literature on international specialisation is rather underdeveloped. The model used in the present thesis relies on a static model, which represents the Rybczynski effect of specialisation. This model is subject to two main critiques; it does not specify a well-defined alternative hypothesis of

specialisation and second, it does not explore the dynamic nature of comparative advantage (see Redding (2002) for an important contribution to this area). As Harrigan (2001) points out there is still a lot of work to be done in order to understand the nature of comparative advantage. An investigation of the dynamics of comparative advantage will improve substantially our understanding about the forces of specialisation.

The framework of productivity convergence is not unique, that one can use to explore the sources of productivity growth. Productivity convergence helps us to investigate the potential of technology transfer, which carries many appealing features for the case of a non-frontier country like Greece. Nevertheless, the use of industry level data permits the use of various different methodological approaches for the sources affecting productivity growth. For instance, it is of particular interest to assess whether general restructuring forces along with standard channels can influence productivity. On this basis, firm dynamics (entry and exit of firms) can be a crucial path of productivity growth at the industry level (Aw et al. (2001) and Haskel et al. (2003)). In such a framework, traditional determinants of growth might drive restructuring efforts attaining a multifaceted role. Export activity can affect productivity directly through spillovers of technological ideas but at the same time reinforces competition within the industry and thus, drives firm dynamics that, in turn, serve as conduits of industry's productivity growth. The implementation of this methodological strategy requires us to estimate the sources of productivity growth as a system of simultaneous equations.

Finally, the formulation of productivity in the thesis is derived from a technical efficiency parameter as specified in Solow's production function. The empirical transformation of this parameter is based on the non-parametric technique of Tornqvist index. These indices can derive from any underlying production function as long as this exhibits some certain characteristics, such as perfect competition in both the labour and product market and constant returns to scale production.

Non-parametric techniques in the estimation of productivity growth do not allow us to assess how productivity is affected when these assumptions are not fulfilled. A chronic debate in the agenda of productivity measurement is focused on providing functional techniques for the measurement of productivity. The recent literature provides many interesting developments (i.e. Data Envelopment Analysis-DEA, Malmquist index, parametric econometric approaches). These different approaches attribute to some desirable properties but they, certainly, have their own limitations. For instance, the use of parametric-econometric models in the measurement of productivity is subject to standard specification problems but they offer researchers the opportunity to quantify the influence of various alternative hypotheses as sources of productivity growth. This can be done by estimating econometrically a cost translog function that provides insightful decompositions regarding the impact of scale and short-run demand effects on productivity. Econometric models of this kind are natural extensions of the non-parametric productivity measures used in the present thesis.

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